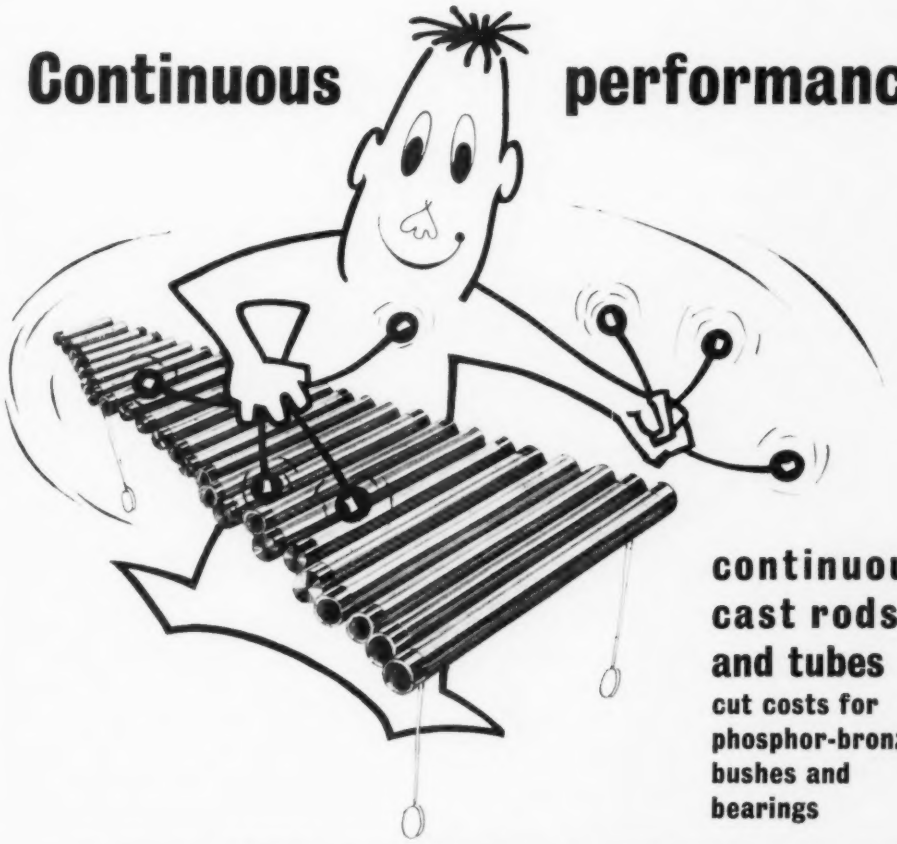
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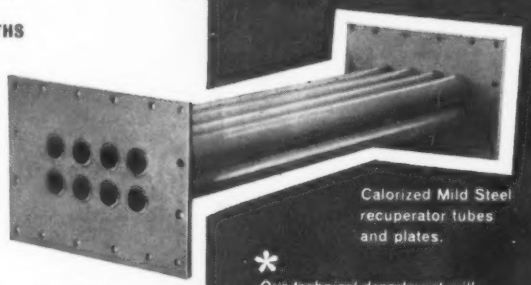
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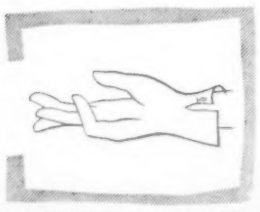
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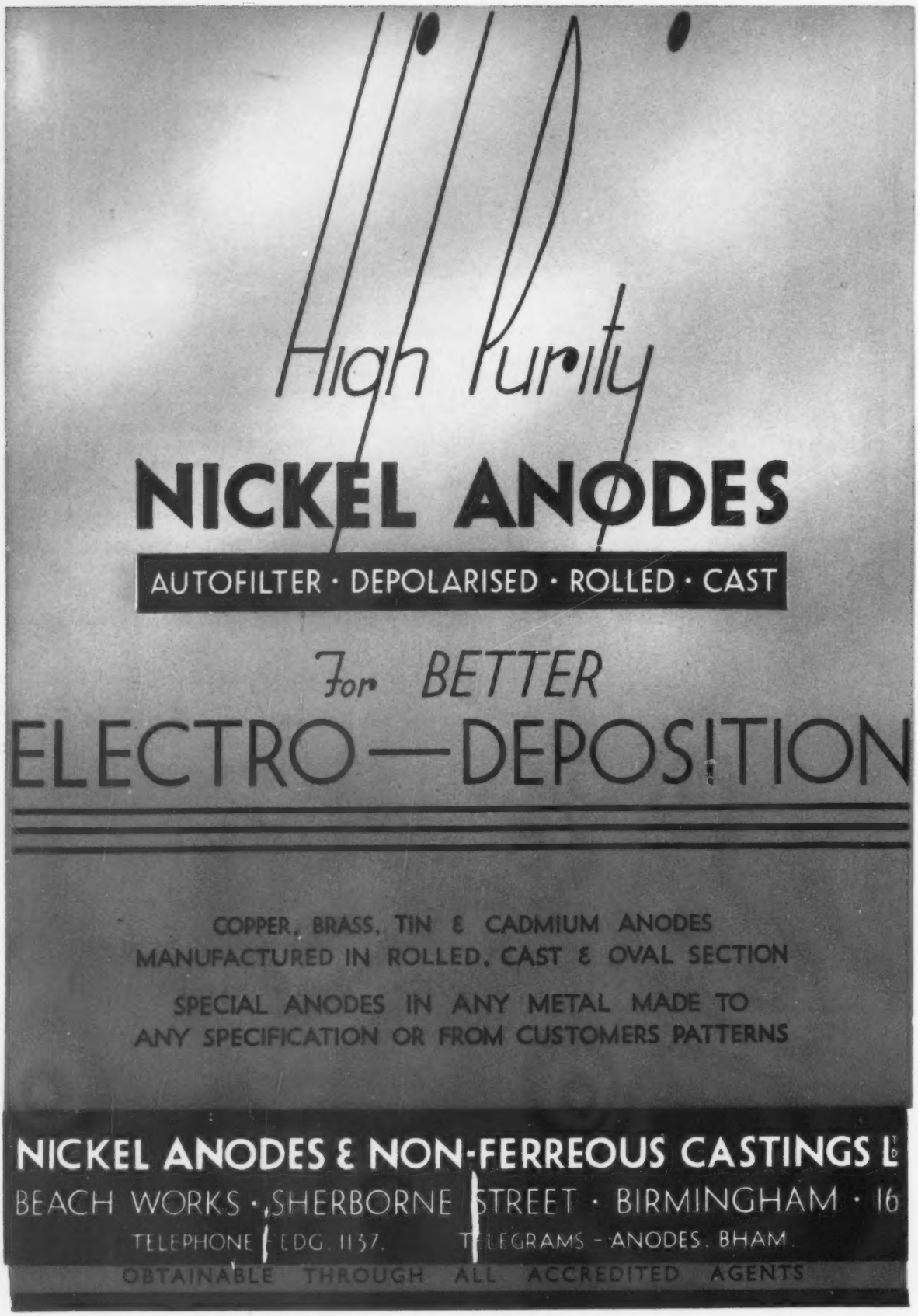
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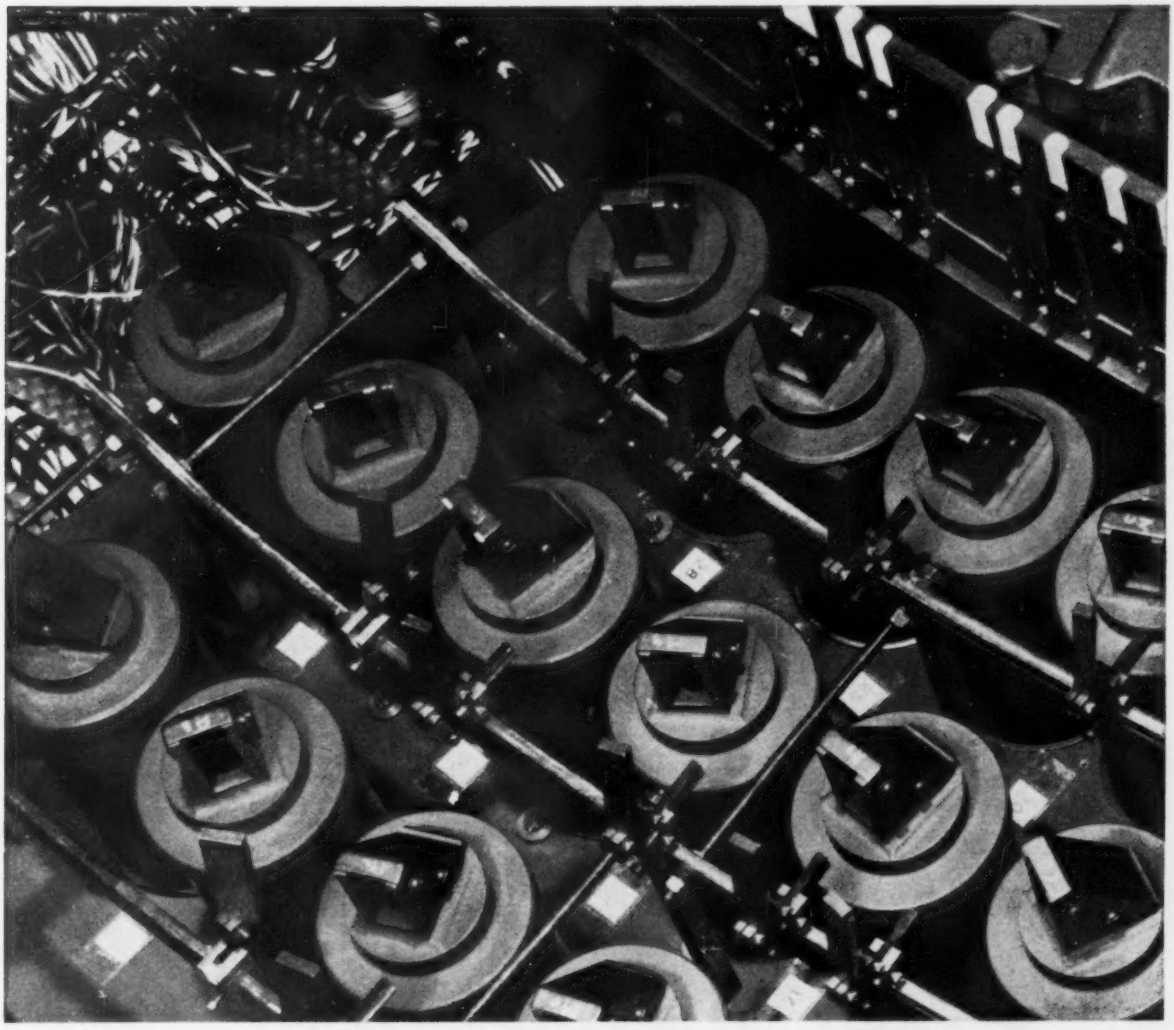
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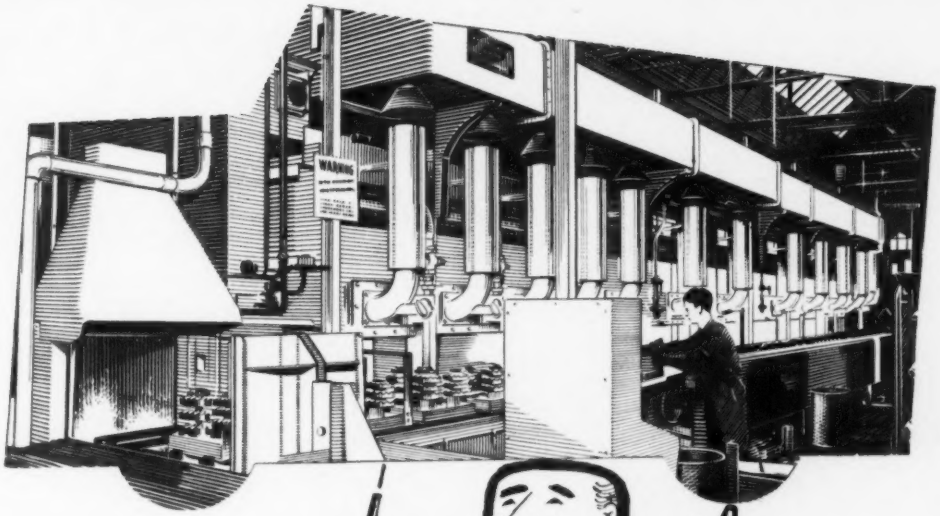
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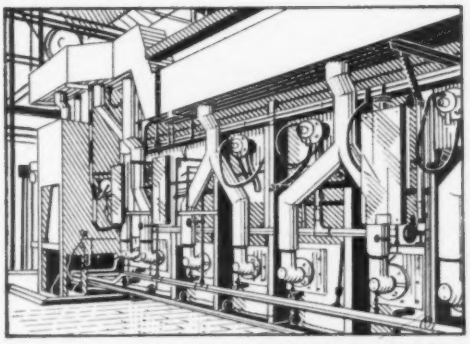
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METAL INDUSTRY

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Stress-Corrosion Cracking

BELIEVED to constitute a reliable accelerated method of determining the relative resistance of copper alloys to stress-corrosion cracking in natural environments, a simple "loop test" is described by D. H. Thompson in a Paper to the American Society for Testing Materials. In the test, strip specimens are simply bent round a mandrel until the ends touch and are held there, thus producing a tensile stress in the outer fibres at the bend. The tear-drop-shaped loops are then exposed to the vapours arising from concentrated ammonium hydroxide solution at room temperature. Before and after exposure to the moist ammoniacal atmosphere each loop is unfastened and allowed to spring back into its natural U-shape and the distance between the ends is measured. The reduction from the original distance is a measure of the progress of stress-corrosion cracking.

As the test is capable of reproducible results if carried out in an unvarying manner, a "standard" way of conducting the test is specified. In it, annealed metal 0·050 in. thick is cold rolled to a thickness of 0·025 in. Cold-rolled specimens are used because they have a higher yield strength, and hence higher fibre stresses at the bend so that they crack more readily. Specimens are sheared to 6 in. by $\frac{1}{2}$ in. and straightened, holes $\frac{1}{8}$ in. in diameter are drilled $\frac{1}{4}$ in. from each end and the strips are bent round a $\frac{1}{4}$ in. mandrel until the ends touch and are held by a twist of copper wire passed through the holes. Strips are held for at least 24 hr. (to dissipate some of the tendency to creep). They are then released, the distances between the ends are measured, and they are refastened. After vapour degreasing, pickling in cold dilute sulphuric acid and rinsing, they are exposed to the vapours from concentrated ammonium hydroxide for a predetermined time.

The length of time (which may range from a few minutes to many weeks) must be found by trial and error. Every 24 hr. the specimens are rinsed in water and the ammonium hydroxide is renewed. At the end of the predetermined time the specimens are removed, pickled, rinsed, dried, and the ends unfastened and the distance between them measured. The percentage relaxation which gives a quantitative measure of the degree of cracking is then calculated. A single figure that represents the resistance of an alloy to stress-corrosion cracking in moist ammoniacal atmosphere is the time required to produce 50 per cent relaxation. This may be found from the relaxation versus time data.

Advantages claimed for the test are its simplicity, the almost negligible amount of equipment required, and the quantitative measure of the progress of cracking. That the percentage relaxation does give a quantitative measure of the degree of cracking has been confirmed by correlating the depth of cracking, determined microscopically, with the percentage relaxation. Although the tests are not so reproducible as those made with more elaborate equipment they are, however, sufficiently reproducible to be informative. One of the obvious uses of the test is to compare the resistance of various alloys to stress-corrosion cracking in moist ammoniacal atmosphere, it being generally agreed that ammonia is necessary to cause stress-corrosion cracking and that the use of a strongly ammoniacal atmosphere is a legitimate accelerated test. The disadvantages are the inability to measure or vary the applied stress and the use of cold-rolled specimens.

Out of the MELTING POT

Some Understanding

WITH a phenomenon as complex as the solidification of a metal, a theoretical consideration of the mechanism by which the process is influenced by ultrasonic vibrations can do little towards reducing complexity and decreasing the gap between theory and experiment. In theory, the grain refinement and the elimination by ultrasonics of columnar crystallization could be due to a change caused by ultrasonics in the thermodynamic properties of the solid and liquid phases, to the heat generated in the process of attenuation of the vibrations, or to an influence on the nucleation frequency in the layer of liquid adjacent to the freezing interface. The first two effects are unlikely to be large enough for practical purposes. This leaves the third mechanism as the most likely one, but throws no light on the detailed mechanism by which the nucleation frequency is affected, i.e. whether by the ultrasonics reducing the supercooling required for nucleation, or increasing the surface activity of nuclei, or by agglomerating subcritical nuclei, or by detaching nuclei from the solid interface, or by other means. Experimental work, while tending to confirm that ultrasonic vibrations exercise their grain refining influence through their effect on the process of nucleation, has so far failed to provide evidence as to the exact manner in which the process of nucleation is affected. From the practical point of view, conclusions from recent experimental work, though useful, are not such as will make ultrasonics an inseparable part of casting processes in the immediate future. One conclusion is that introduction of the vibrations via the already solidified metal is more efficient than via the still liquid metal. The former was achieved in a continuous arc melting and casting process by brazing a magnetostriction generator to the bottom end of the starter bar, which was made of the same metal as that being cast, and, in a zone melting process, by brazing a tapering transducer horn to one end of a long thin specimen. In the latter case it was necessary to vary the frequency with distance to the molten zone to ensure resonance at the interface. Scattering from the sides, and the parabolic shape of the interface, made this unnecessary in the case of ingots with diameters comparable to or greater than the sound wavelength. It has been estimated that energy inputs to the interface of less than 5 W/cm^2 are sufficient to suppress columnar crystallization.

Unwanted

NATURAL spontaneous reaction to excessive specialization has received little attention from those who bemoan the evils of the alleged excessive swing in that direction. The consequences of this reaction have, however, been observed on several occasions by those who have been inclined to set out to pander to the trend, though even they have as yet failed in all cases to draw the corresponding conclusions. One way of pandering to narrow specialization has been by arranging to provide specifically selected information that would be of direct value to specialists, the preliminary selection being intended to save them time which they would otherwise have to spend in wading through a much larger volume of less specific material. With this logical objective in view, periodicals with more and more restricted titles and abstract journals covering narrower and narrower fields have made their appearance. If carried too far, however, such specialization encounters a certain reaction, followed by a drop in demand. It also very soon reaches a point at which supplementation by more general sources becomes necessary, resort to which, however, inevitably brings with it the risk of a certain amount of duplication being encountered by readers. Examined more closely, this reaction to spoon-feeding with specialized information, and specialized information only, appears to derive from an uncertainty on the part of the recipients as to their exact needs in this respect. All of them will be able to remember occasions when a sudden flash showed up the value of a bit of information superficially unrelated to their interests, and one that they would certainly not have come across had they been relying on offerings of purveyors of carefully hand-picked material. How can the latter be expected to know (if, in fact, knowing is the right or only criterion) what the recipients of their offerings need or what will be of benefit to them when the recipients themselves are usually far from certain and, in the long run, tend to react accordingly.

Some Significance

RESULTS of quantitative chemical analysis, taken on their own, always seem quite satisfying. The method of analysis having been suitably chosen, the degree of accuracy will be adequate for the purpose. A known degree of reliance can therefore be placed on statements to the effect that, for example, the given aluminium alloy contains 4·4 per cent copper, 0·75 per cent magnesium, etc., etc., or even 0·002 per cent sodium. Reliance on such results should never be quite blind, however. Where the possibility exists, a check to see that the concentrations of all the constituents add up to 100 per cent is always useful as a guard against experimental errors or misprints. In some cases, a check against common sense may be possible and is always advisable. It will show up such results as those published a long time ago for the amount of aluminium going into solution in milk boiled in an aluminium saucepan, which results were subsequently shown by simple calculation to suggest that the saucepan could be expected to dissolve away completely as a result of a few years of normal regular domestic use for boiling milk — a most unlikely happening. Apart from such simple checks on analytical results, it may be necessary to consider the significance of the latter in other directions. It sometimes happens that analysts in the first flush of enthusiasm over the development of a method of performing a hitherto impracticable analytical *tour de force*, apply it in circumstances in which the results obtained—assuming their significance — throw new light on the particular state of affairs. An example of such possible significance is provided by the results obtained when a recently developed "addition" method for the flame-photometric analysis of the sodium and potassium contents of aluminium was applied to samples taken from different portions of blistered aluminium plates. These results showed that the increase in the concentrations of the alkali metals near the blisters was relatively much larger for potassium than for sodium, suggesting that the potassium plays a much more important part in the blistering mechanism than does sodium.

Skimmer

RECENT DEVELOPMENTS AND SOME METHODS OF APPLICATION

Vacuum Techniques

By T. THORLEY A.M.I.M.E., A.M.I.E.E., F.I.M.

In this article vacuum technology has been treated broadly, with reference principally to the more recent developments and avoiding, as far as possible, matter dealt with in the many excellent text-books now available. Practical aspects are emphasized, the subject being treated from the point of view of the practising metallurgist. Originally presented before a meeting of the Birmingham Metallurgical Society, some of the ideas it contains have not hitherto been covered adequately in the literature.

VACUUM techniques have been practised on a large scale in the electric lamp and valve industry since the turn of the century and vacuum metallurgy was practised very soon after, but the equipment available was small and the pressures used were in the range sometimes referred to today as "suck" rather than vacuum. Oil diffusion pumps became available in the 1930s but were of small sizes only up to the early post-war years. Towards 1950 the need for larger pumps became insistent and developments were rapid. Big strides in vacuum metallurgy thus became possible and furnace charges can now be considered in tons rather than pounds. Heavy outgassing is encountered during melting cycles and in the earlier stages of development, pressures of a few microns were considered adequate for many applications. Attention was consequently paid to booster pumps of both the oil vapour and Rootes mechanical types, and quite large units are now available.

Developments in the nuclear field pin-pointed the need for large pumping speeds at very low pressures, and oil diffusion pumps as large as 32 in. became available.

High pumping speeds necessitate large pipe, port and valve diameters and major problems in valve design have been encountered due to the high mechanical loading consequent upon the large diameter. Difficulties have also been met in service through leakage caused by particles of solid matter deposited on the seats, and elimination of this trouble does not appear to have been achieved as yet in all cases.

When hot, the more reactive metals remove most gases more effectively than do the pumps themselves and consequently very low leak rates are essential when processing these materials. To ensure continuance of these low leak rates in service demands the highest possible standards of design, construction and especially maintenance. The problem is made more difficult because in many cases the components are large and heavy but still need to be handled in a manner approaching that more usually associated with instrument work.

Pumps

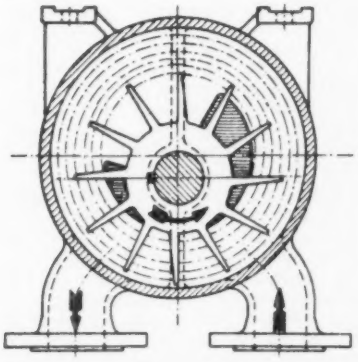
For small units, the usual arrangement of a vane type rotary pump, followed by a diffusion pump, normally meets the need, though in cases where pressures not lower than a micron or so are sufficient a two-stage rotary pump alone may be adequate. Use of gas ballasting with rotary pumps enables atmospheres containing vapour to be handled with reduced danger of the vapour condensing in the rotary pump oil and backstreaming into the system at a later stage in the operating cycle. Care has to be taken, however, because gas ballasting raises the ultimate of a rotary pump to about 0·5 or 1 mm., and at this level a diffusion pump is not adequately backed.

As equipment size increases, the cost and bulk of a single backing pump become uneconomic and two-stage backing is desirable. Rotary pumps are available in which two stages are incorporated in one body, but for the larger equipment it is quite usual to use separate pumps. Of these, the first stage pump, which exhausts to atmosphere, can be much smaller than the second-stage pump. Since the pressure at the delivery end of the second-stage pump is much lower than atmospheric, the possibility of vapour condensing is very much reduced and only the first-stage pump needs to be adapted for gas ballast admission. Thus, with this arrangement, gas ballast can be used continuously without impairing the backing pressure at the diffusion pump. In cases where large quantities of vapour have to be handled, an inter-stage condenser can be used with advantage.

With separate backing pumps several combinations are possible; a rotary piston pump preceded by a smaller piston or vane type pump can be employed or, alternatively, a Rootes pump preceded by a rotary piston pump. Rootes pumps preceded by water ring pumps have been used in some equipment and form a good combination where appreciable amounts of solid matter may be carried over from the melt. In this case, two Rootes pumps in series normally follow the water ring pump because the minimum pressure developed by the latter is inevitably rather high.

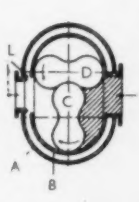
Use of a Rootes pump for the second stage is becoming more popular, and is attractive because the Rootes pump does not use oil, apart from that necessary to lubricate the bearings and gears; there is thus less danger of oil vapour contamination of the furnace atmosphere.

For medium or large size furnaces, several alternative pumping arrangements are available to follow the backing pumps. If the minimum operating pressure is not required to be lower than a micron or so, booster pumps are eminently suitable; these can be of either the oil vapour or Rootes mechanical type. Oil vapour pumps have an effective range from rather less than a micron up to 500 microns, with



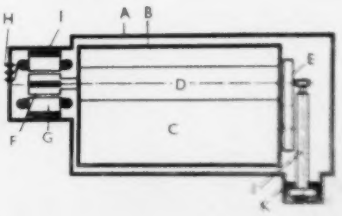
Left—Schematic cross-section of water ring pump

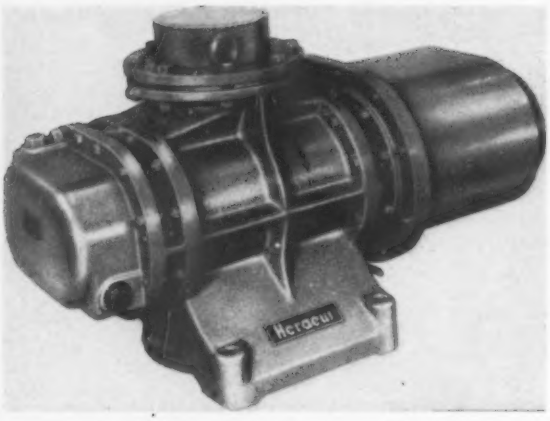
[*Courtesy Heraeus GmbH.*



Right—Schematic cross-section of Rootes booster pump

A—Leak-tight outer casing. B—Inner housing. C & D—Lobe-type impellers. E—Gears. F—Rotor of 3-phase squirrel-cage motor. G—Electric leads for motor. H—Cooling water for motor. I—Oil pump to lubricate drive gears and bearings. J—Oil reservoir. K—Opening between pump chamber and outer casing.





External view of Rootes backing pump [Courtesy Heraeus GmbH.

a decreasing but still appreciable pumping speed up to about 1 mm., and have a critical backing pressure usually in the range of 2 to 5 mm. Rootes booster pumps will operate effectively from a micron up to about 10 mm. with little change of speed and will attain pressures lower than 0·5 micron. The Rootes booster has the advantage that it does not involve the heating and cooling of an oil boiler and can thus be switched in or out as desired without any delay. With oil booster pumps, a valve can be installed on the high vacuum side to enable the pump to be isolated and the tank opened up to atmosphere, but such valves tend to give trouble because of the difficulty of maintaining the seat free from deposited particles and thus leak-tight when closed.

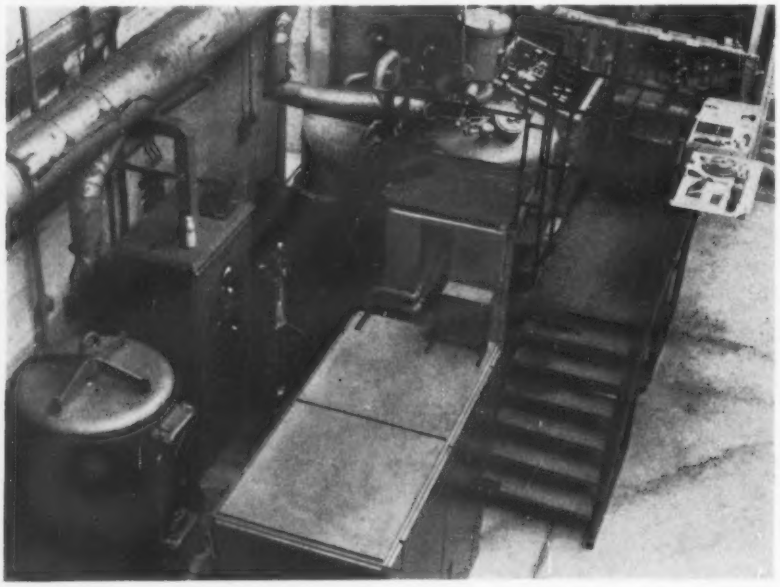
Where operating pressures lower than one micron are required, two alternative schemes are available:

(1) A diffusion pump preceded by suitable backing pumps.

(2) Diffusion and booster pumps in parallel, preceded by a common backing system.

In general, the first scheme is usually adequate for annealing furnaces, etc., which do not involve heavy outgassing during the operating cycle, and the second scheme is desirable for melting or sintering furnaces when very low pressures are required for purification purposes, etc. With melting or sintering operations, heavy outgassing often occurs either during the pumpdown or in the course of the operation, and the booster pump will deal with this effectively, after which it can be switched out to enable the diffusion pump to produce the required low pressure. When operating this system, the Rootes booster offers distinct advantages because it can be switched in or out as desired, either manually or automatically, and does not require a valve or refrigerated trap on the high vacuum side as does the oil booster.

Medium size vacuum induction furnace equipment [Courtesy I.C.I. (Metals Division) Ltd.



When the gas load to be handled is principally hydrogen it is necessary to remember that, whilst the oil vapour booster pump has a higher speed for hydrogen than for air, the Rootes booster has a slightly lower speed for hydrogen. This is because with vapour pumping, the smaller hydrogen molecule is handled more efficiently, whereas in the Rootes pump, the clearance of about 0·015 in. to 0·03 in. around the rotors permits easier backstreaming of the smaller molecule. The simplicity and operating flexibility of the Rootes pump has much to recommend it and if the foregoing point is likely to be of major importance, a larger size of Rootes pump could be used. When considering any increase in initial cost, it has to be remembered that quite small reductions in operating cost can very soon outweigh quite considerable increases in initial cost. The author is convinced that insufficient consideration is very often given to this aspect.

Ultra High Vacua

Considerable interest is being shown at the moment in ultra high vacuum systems, that is, systems operating at pressures lower than 10^{-8} mm., and whilst the present position appears to be far from clear certain general comments can be made.

For work in the ultra high vacuum range two requirements become essential:

(1) Elastomer seals have to be eliminated.

(2) The system must be baked at temperatures not less than about 450°C.

Elimination of elastomer seals is essential to permit the equipment to be baked. It is also necessary because, even though the joint faces are highly finished and meet metal to metal inboard of the "O" rings, minute passages will exist between the metal faces, and these will permit outgassing from the "O" ring, especially so because the vapour pressure of the protective grease film is not lower than about 10^{-8} mm. Hg.

Baking is necessary because release of surface gases is very slow at temperatures below 200°-300°C. and baking at about 450°C. for 15 or 20 hr. will reduce the outgassing rate to something approaching one-millionth of the rate which would be achieved in the same time by pumping alone.

Joint seals in ultra high vacuum equipment are usually made by means of copper sheet or gold wire gaskets used in conjunction with step or wedge type flanges; valves also must, of course, be of all-metal construction.

For pressures in the ultra high vacuum range ionization gauge heads of the Bayard Alpert type are necessary since ordinary ionization gauge heads may generate soft X-rays which give rise to gross reading inaccuracies.

The whole field of ultra high vacuum is undergoing considerable development, and there does not yet appear to to be any decisive information regard-

ing pumping systems. Pumps involving the gettering action of either barium or titanium, in some cases aided by ionization pumping effects, are undergoing development, but information regarding them is sparse. It does not yet appear to be clear whether such pumps alone will be adequate or whether they will have to be preceded by normal vapour diffusion pumps. Getter or ionization pumps appear to function quite well with the heavier molecules but their speed for hydrogen falls seriously. Troubles have also been experienced due to the difficulty in outgassing the gettering material and feed mechanism.

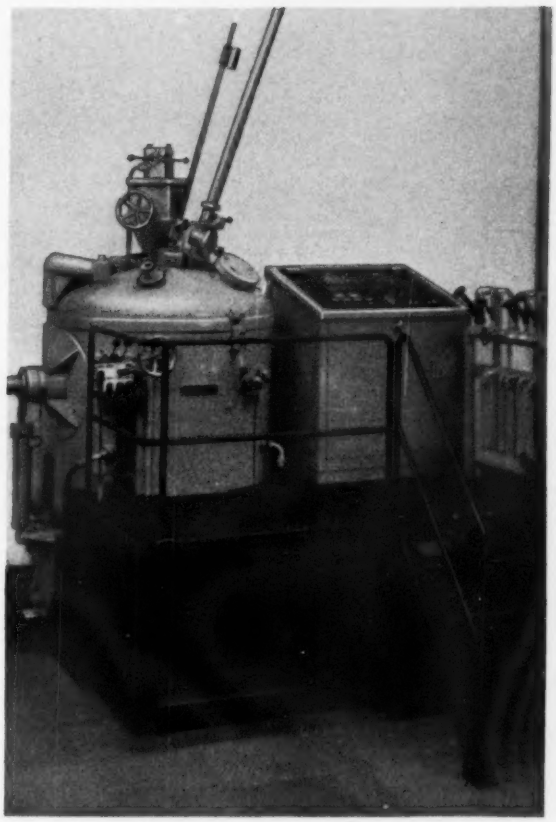
Pressure Measurement

In vacuum systems, pressure measurement almost always presents some difficulty and errors of considerable magnitude are probably present more often than not. One major factor is that of furnace atmosphere since, whilst vacuum gauges are normally calibrated for use with dry air, their calibration differs considerably for other gases. For instance, used with a hydrogen atmosphere, the readings of a Pirani gauge would be rather more than $1\frac{1}{2}\times$ the true pressure, whereas an ionization gauge of either the hot or cold cathode type would read about $\frac{1}{4}$ or $\frac{1}{5}$ of the true pressure. Thus, in the overlap range of thermal conductivity and ionization gauges connected to the same chamber, reading differences as great as 5 or 6 to 1 could occur even if everything were in order. It should be emphasized that, apart from the pump-down period, furnace atmospheres rarely contain more than 20 or 25 per cent of air and often even less than this. Hydrogen is normally a constituent of melting furnace atmospheres and, in some cases, may be by far the major constituent.

When pressures appreciably lower than one micron are involved, outgassing of the gauge head is a source of error, and the effect is quite often intensified by use of small bore connections of undue length. Even when using a 1in. bore connection, only a few inches long, outgassing may affect the reading for an hour or more if the gauge head has been exposed to atmosphere for a day or two before using, and this period may be increased appreciably if the head is contaminated.

Considerable care has to be taken when using cold cathode gauges of the Penning type because of the unstable kink which often appears in the calibration of this type of gauge due to changes in the glow discharge mechanism, and the author has more than once demonstrated a Penning gauge reading 3 microns when connected by a short wide bore connection to a vessel exhausted to something approaching 10^{-5} mm. Incorrect readings can also be caused by a Penning gauge not firing properly, and the author has seen a gauge of this type dithering round about 1 micron when connected to a system which was certainly at 50 microns or so pressure.

Pressure readings lower than the true pressure can result due to the pumping action of an ionization gauge. This effect does not usually give trouble, except with static systems, unless the gauge tubulation is too small, and even then its effects may not be noticed due to a tendency to balance between outgassing and ionization pumping. These considerations emphasize that the connections used for ionization gauges in particular should be of wide bore and as short as possible; connections as small as 0·5 in. have been used, but these obviously increase considerably the danger of incorrect readings especially because pressure changes in melting or sintering furnaces are often quite rapid.



Small vacuum induction furnace
[*Courtesy Heraeus GmbH.*

Errors in gauge reading due to contamination of the gauge head are quite usual with melting or sintering furnaces since considerable amounts of material are normally volatilized off from the charge. Thermal conductivity gauges are usually affected to a much greater extent than ionization gauges and even after a short period of use a Pirani gauge should be treated with some measure of suspicion. Such gauges are also, in some cases, subject to calibration drift due to changes of ambient temperature, and changes in resistance of the sliding contacts on the calibration adjustment resistances are another source of error.

The normal practice is to use thermocouple or Pirani gauges for pressures around or above one micron and Penning cold cathode gauges below one micron. Hot cathode ionization gauges are much more accurate and reliable than Penning gauges but filament life is short at pressures around 10 microns, and failure may occur immediately at pressures not much higher than this. There is also a danger of reading inaccuracies due to poisoning of the filament. Alphatron radiation ionization gauges can be used throughout the range from about 10^{-4} to 500 mm. Thermistor gauges can be employed for pressures greater than one micron, but these are in limited use as yet; claims have been made to the effect that they are less liable to contamination than Pirani gauges.

Leak Detection

Detection and elimination of leaks are two of the biggest difficulties encountered in vacuum practice and unless the correct approach and technique are used much time may be lost. It must be emphasized, however, that if the design of the equipment is sound and maintenance is kept at the highest possible level, the amount of time lost due to leaks should be very small indeed.

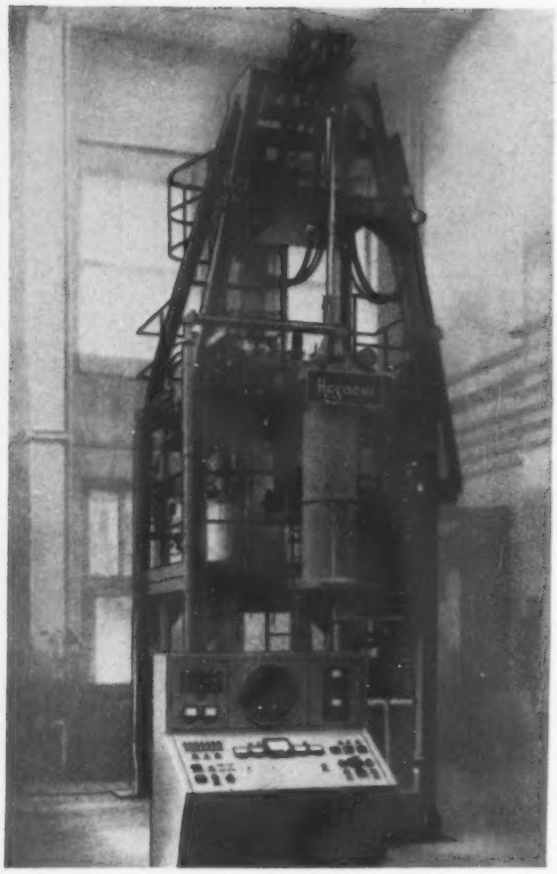
Leak rates have been specified in various units but the most usual is the lusec; this unit specifies a leak of size that would pass 1 L. of air at a pressure of one micron during one second.

The methods normally employed for detection of leaks are—

(1) Soap solution painted externally on the vessel, which is held at a pressure greater than atmospheric.

(2) The gas discharge tube.

(3) Change in response of a vacuum



Vacuum arc melting furnace
[Courtesy Heraeus GmbH.

gauge due to a change in the composition of the atmosphere within the vessel.

(4) The palladium barrier leak detector.

(5) The halogen sensitive detector.

(6) The mass spectrometer.

The first method is only of use when gross leaks are present and no further comment is necessary apart from a reminder that care should be taken to ensure that the internal pressure employed does not exceed the safe working pressure for the vessel. It is perhaps worth pointing out that leaky pressure regulators or valves are not unusual and that such items can result in the pressure rising much higher than intended. If it is possible to avoid the use of ordinary compressed air this is desirable because the high oil vapour content is likely to contaminate the vessel and may cause considerable trouble later.

Gas discharge tubes also are only suitable for the detection of relatively large leaks and can only be used when it is possible to maintain the pressure in the discharge tube within the range from about 10 microns to a mm. or so. This device, as is well known, depends on the change in colour of the discharge consequent upon the probe gas entering the system.

The most usual combination in the third group is that of a Pirani or thermocouple gauge employed in conjunction with hydrogen as a probe gas; of the two gauges mentioned, the Pirani is normally more sensitive. Probe media such as butane and trichloroethylene have been used, especially in conjunction with ionization gauges.

Rapid diffusion of hydrogen through a heated barrier of palladium forms the basis of operation of the fourth method which enables a high degree of sensitivity to be achieved. Method (5) utilizes the fact that emission of ions from a heated platinum cathode is increased markedly in the presence of a halogen; the probe medium used with this detector is usually Freon.

Of the methods listed, the mass spectrometer is the most sensitive and also the most positive. This instrument analyses the furnace atmosphere and is set to respond only to an increase in concentration of the probe gas. Helium is the best probe medium but, unfortunately, its cost in this country is very high indeed. However, mass spectrometers which can be adjusted to any one of a range of gases are available and, with these, gases such as methane or argon can be used.

Sensitivities claimed for the various leak detection equipments range from about 10^{-2} lusecs for the hydrogen Pirani to less than 10^{-6} lusecs for the mass spectrometer. Whilst these sensitivities can undoubtedly be achieved in suitable circumstances, the minimum detectable leaks on medium or large equipments when tested under operating conditions are far larger. In a vacuum system of appreciable size, change in composition of the furnace atmosphere due to entry of the probe gas through a small leak is gradual, even when the leak connects direct with the vacuum space. Unfortunately, many leaks consist of a tiny aperture at the outside entering into a cavity, such as exists in most joints or at the root of a weld, and passing from there through a second tiny aperture into the vacuum space. Pumping rate from the cavity into the vessel is very slow and thus dilution of the atmosphere in the cavity by the probe gas is gradual. The gas passing into the vacuum system does not contain a significant proportion of probe gas until appreciable time has elapsed and change of composition of the atmosphere in the vacuum system is very slow indeed. In these circumstances, the overall response time from the probe gas first entering at the outside until sufficient concentration has built up in the system to affect the leak detector is often a minute or so and may exceed 20 min. in some cases. For convenience, the two types of leaks will now be referred to as direct and compound.

With the hydrogen Pirani system, evidence of a leak is given by an apparent change in pressure as recorded by the gauge. Even after prolonged pumping it is difficult to obviate pressure changes completely and in addition Pirani gauge readings are not infrequently subject to slight drifts; thus the very gradual change in reading consequent upon the entry of hydrogen tends to become obscured by the real pressure changes or calibration drifts which are also present. This situation applies even in the case of direct leaks but is obviously much worse with compound leaks. With a furnace having a volume of the order of 1,000 L. the smallest leak which can be detected by the hydrogen Pirani system is probably at least a lusec even in the case of direct leaks, and compound leaks as large as 60 lusecs can remain undetected. Additional to the difficulties already outlined is the effect of hydrogen background which is normally present in vacuum atmospheres.

The palladium barrier leak detector also relies on hydrogen as a probe gas but as this instrument responds only to the quantity of hydrogen present its indications will be less affected by pressure changes than the hydrogen Pirani detector; its sensitivity also is much higher than the hydrogen Pirani.

The halogen sensitive detector responds only to the presence of halogen and has a high sensitivity; unfortunately it will respond to any halogen, and consequently the presence in the furnace of chlorinated oils or the chloride deposits which sometimes form by

volatilization from the charge will cause spurious leak indications.

Mass spectrometers respond only to the presence of the gas for which they are set, and helium is the best possible probe medium, both because of its absence as a background either in the furnace or the atmosphere and also since its small atomic diameter facilitates high leak-in rates. Unfortunately, the price of helium in this country is very high and its cost for general testing is prohibitive. However, mass spectrometers which can be adjusted for any one of a range of gases are available and with these probe media such as methane or argon are adequate for general testing. There is always some background of hydrogen, argon and various hydrocarbon gases in the furnace atmosphere and this reduces sensitivity somewhat. In practice, however, the potential sensitivity of the mass spectrometer is so high that leaks less than 10^{-3} lusecs can be detected readily and without ambiguity, when using methane or argon. In the presence of a probe gas background in the furnace, pressure fluctuations at the leak detector take-off point can affect readings due to gas density changes, but no trouble is experienced during normal testing even after only a very short pumping time. If exceedingly difficult leaks are involved, recourse can always be made to helium, but this will rarely be necessary.

One big advantage of the mass spectrometer is that, having found and rectified the leak, there is no need to pump right out and do a leak rate check, since a retest with the leak detector will quickly and positively confirm whether the leak has been effectively repaired or not. As will be realized, this saves very many hours of operating time with a resultant substantial saving in operating costs. Within the author's experience, leaks of a few tenths of a lusec have been detected and the total time for testing, rectifying, unloading the furnace and recharging has been less than 2 hr.

Design and Maintenance

Equipment design and maintenance are the most important aspects of vacuum technology. The first thing to be considered is pumping capacity, and this should never be skimped. It is always a wise measure to install pumps considerably larger than preliminary calculations indicate. For equipment such as annealing furnaces, etc., it is desirable for the pump speed in litres per second to be not less than two or three times the volume of the vessel in litres, and for melting or sintering furnaces this figure should be increased to four or five times. The backing pumps should be capable of handling two or three times the throughput of the diffusion pump in order to ensure that the latter is not swamped by sudden bursts of outgassing. If of adequate size from that point of view, the backing pumps will usually rough the vessel down in reasonable time. Equipments are in use with pumps much smaller than suggested, but in these circumstances pump-down times become unduly lengthy. It has again to be emphasized that quite appreciable savings in initial cost can very soon be lost by quite moderate increases in operating times. Cost apart, inadequate pumping capacity often results in processes being carried out at pressures higher than are desirable even in spite of increased pumping times.

The importance of furnace layout is often not appreciated and insufficient thought is given to this aspect. Even quite moderate lengths of pipe can cause a major reduction in speed. For instance, an 18 in. length of 9 in. diameter pipe connecting a 9 in. diffusion pump to the furnace chamber will reduce the speed at the chamber to about 60 per cent of that at the pump. The resistance of a bend or elbow is about 2½ times that of an equal length of pipe. Considering these facts it is quite obvious that even small departures from the ideal layout can reduce pumping speed quite disproportionately.

Demountable joints are always a potential source of leakage troubles and should be kept to the absolute minimum. In addition to potential leakage dangers there is also the question of outgassing. Joint faces normally bed down metal to metal, but even with the best of workmanship there are always minute passages across the faces to the "O" ring groove. At the groove itself there will normally be a small cavity which will contain air or moisture initially and this will have to be pumped out through the minute passages between the flanges. At first thought this may seem unimportant, but when it is remembered that the pumping speed through these minute passages is very slow indeed and that 1 c.c. of air or 0·001 c.c. of moisture at atmospheric pressure become 75×10^6 and 94×10^6 c.c. respectively at 10^{-5} mm. Hg, it will be realized that a few joints of poor design can increase outgassing time by an appreciable amount. This problem of cavities connected to the vacuum space by very small passages is prone to occur in items such as electrical lead-in connections, etc., and careful watch should be kept when designing such joints.

Union type joints are extensively used for small pipes and give yeoman service. They are, however, rather susceptible to damage which is sometimes difficult to observe, and which can only be corrected either by replacement or by removal and remachining. On the other hand, "O" ring sealed, bolted, flat flange joints are easily checked and, if damaged, can soon be reconditioned *in situ* by bedding flat with small surface plates. Joint faces should always be highly finished and even the finest machining or abrasive marks should run parallel and not across the direction of the "O" ring. Polishing is always worth while because, in addition to improving joint contact, even the smallest imperfection is immediately visible on a polished surface. Small bruises, in particular, are extremely difficult to detect on smooth machined surfaces.

Cooling water circuits should be protected by filters, and it is essential to install a main filter and also subsidiary filters on all circuits involving small passages, such as diffusion or Rootes pumps, etc.

A close watch should be kept on furnace leak rate and a leak rate check should be made, if possible, at the beginning or end of each run. These tests should be carried out over the maximum possible period because determinations made over a few minutes leak up time can be misleading.

Extreme care in maintenance always pays handsome dividends by reduction in loss of operating time due to leakage troubles, and given adequate maintenance it should be possible to run for very long periods without any undue delay. The important thing is to make sure that maintenance standards do not deteriorate, due to familiarity breeding contempt, because this is fatally easy.

Stud Welding

RECENT tests carried out by Crompton Parkinson (Stud Welding) Limited on the cast metal produced by an aluminium stud weld showed that this suffered from impurities derived partly from the film of oxide and partly from the residue of a drawing lubricant on the stud, and further aggravated by atmospheric contamination during the weld cycle. The film on the stud was removed by skimming it in a lathe: the contamination was dealt with by enclosing the weld zone in argon gas.

The inert gas is introduced and contained in the weld zone through a brass shroud which goes around the stud and ferrule in the weld position. A valve attachment at the base eliminates gas wastage by releasing the argon flow only when the hand tool is in position. The use of the argon attachment has been completely successful for aluminium alloy studs up to and including $\frac{7}{8}$ in. diameter.

On ½ in. studs the complete prevention of porosity set a greater problem, and to overcome the slight reduction in strength caused by microscopic porosity, the weld base area was in effect increased. This was done by making use of the metal displaced when the stud is returned to the molten pool. Investigations showed that fusion did not occur between the displaced metal and the stud sides because the stud periphery was too cold. This led to the development of a preheat arc unit, the function of which is to heat the stud to the required temperature immediately before the weld is made. In practice, it is found that a current of approximately 70 amp. and a duration of 3 sec. give the desired conditions for a ½ in. alloy stud.

Products and Processes

TRENDS IN THE DEVELOPMENT, APPLICATION, PROCESSING, DESIGN AND WORKING OF NON-FERROUS METALS AND THEIR PRODUCTS

Laboratory Melting of High Melting Point Metals

A LABORATORY-SIZE, consumable-electrode, skull-melting and casting furnace equipped with a water-cooled copper ladle has been developed by the U.S. Bureau of Mines for studying the interrelationships among variables associated with skull melting and casting high-temperature metals. Although additional work is necessary to determine the extent to which the information obtained can be extrapolated to larger furnaces of the same type, many casting characteristics of metals and alloys can be determined on equipment of this size.

The ladle, which is a tilt-pour or over-the-lip type, has a volume of approximately 30 in^3 and provides up to 20 in^3 of molten metal for castings. Castings of various reactive and refractory metals, including zirconium, titanium, hafnium, niobium, molybdenum, tantalum and tungsten, have been produced. In addition, castings of iron, chromium and copper have been made.

The versatility of the equipment has been demonstrated by the form and variety of material melted. The equipment should be particularly useful for producing metallurgical specimens where homogeneity in cast material would be beneficial. As many industrial and college laboratories are installing cold-mould arc furnaces, the fact that the casting equipment can be only a modification of a conventional furnace is a definite advantage.

Rapid Moulding for Foundry Patterns

AN intricate foundry pattern for the manufacture of rotary compressor unit bodies for Cooper-Stewart Engineering Co. Ltd., of Letchworth, was recently cast in "Araldite" epoxy resin by J. Hobkirk Sons and Co. Ltd.

As a pattern material, "Araldite" has the advantage of requiring no cleaning or fettling before use whereas a metal pattern would inevitably need some time spent on it. The wear properties of "Araldite" are also extremely good.

Separating Powders from Solution

A DRY powder of predetermined particle size and bulk density from solutions, suspensions or emulsions can be produced in a device recently introduced by Engineering Appliances Ltd. In this machine, the IWK spray dryer, the liquid to be dried is atomized into a drying tower by means of a nozzle. Hot unsaturated air led in simultaneously, quickly evaporates the moisture contained in the small droplets. The powder is then extracted, either from the conical section of the tower or from a first stage separating cyclone. In both cases it is quickly removed from the detrimental effects of saturated air. Further extraction of fine particles in the exhaust air may be achieved by secondary cyclones, wet washers or hose filters, thus ensuring maximum recovery. These smaller particles are returned to the liquid to be spray dried for re-circulation.

Complete industrial plants are available in single tower construction up to a capacity of 4,500 lb/hr. water evaporation; also in "package" units for experimental or small batch production of between 10-20 lb/hr. water evaporation capacity.

This process is most suitable for delicate substances, the finished product being dried without alteration in composition or effectiveness. A testing service is also available to determine the most suitable drying conditions for individual products.

Rapid Tinning of Aluminium

A LOW TEMPERATURE fluxless solder, Tin-A-Lum, enables tinning of most metals to be readily carried out. True intergranular penetration and some alloying are claimed for the soldered joints, and the soldered joint is claimed to have a strength at least as great as that of the parent aluminium. Tinning can be carried out with a soldering iron or flame, and zinc, tin, pewter, magnesium, copper, as well as aluminium and its alloys have been joined. On copper, brass, and ferrous metals normal fluxes are recommended. The solder has been corrosion-tested in South Africa, and its heat and electrical conductivities are good. It is being made in this country by Industrial Synthetics Ltd.

Chemical-Resistant Monolithic Flooring

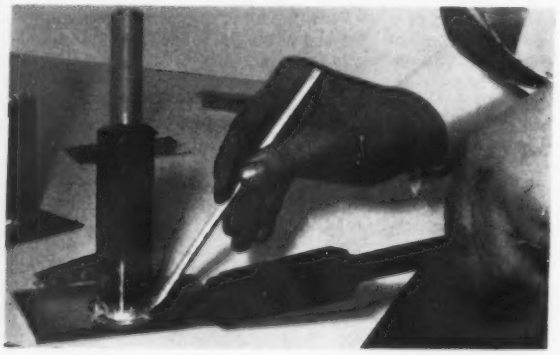
PROGRESS in the techniques of manufacture of epoxy resin cements have made practicable a chemical-resistant flooring compound that can be trowelled, provided the sub-floor is good, dries in 24-48 hr., though seven days is necessary for full curing, and is available in a variety of colours.

The physical and chemical attributes of the finish are dependent primarily upon the resin/filler ratio. It can be assumed that, having the resin content to provide optimum chemical resistance, Corro-Proof "PXY" Monolithic Floor-



Left—Foundry pattern moulded in "Araldite" with the finished casting alongside

Below—Soldering a tube to a flat sheet with Tin-A-Lum solder, a low temperature solder for aluminium and a variety of other metals



ing, as it is called, will be stronger than concrete. The specification for the filler can be varied, although in most cases this is a selected silica sand. In special cases, however, alternative fillers can be incorporated if excessive wearing or slip problems have to be combated.

This epoxy resin cement is a product of Corrosion Technical Services Ltd.

Lightweight Torch for TIG Welding

AIR-COOLED and water-cooled argon welding torches in both pencil and angled types for manual welding, machine torches for automatic welding, and spot guns with control units for TIG spot welding are included in the range now being marketed in Great Britain by Interlas Limited.

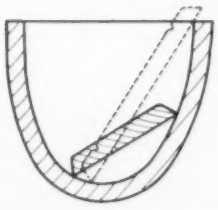
Features of these argon torches are the very light weight (only 3 oz.) and the patented transparent Vycor nozzles, which allow unrestricted visibility of the work and save 20 per cent argon gas consumption. Pencil models can be fitted with 45° and 90° angled nozzles, in addition to straight nozzles. As they use only 3 in. long tungsten electrodes, which can be used down to the last ½ in., the overall height of the torch in use is reduced to an absolute minimum for easy access inside small diameter tubes and other such confined spaces.

Air-cooled models can be supplied in either 100 amp. or 130 amp. capacities, while water-cooled and machine torches are of 350 amp. capacity.

The high rating of the water-cooled models, combined with their small size (1 in. diameter) and light weight, is made possible by the design, which permits the circulation of cooling water right to the tip of the torch, obviating any cooling-off time. Machine torches, 9 in. long with a 24 or 32 pitch rack, can be fitted to any existing oxy-acetylene cutter to provide a fully automatic welder.

Longer Crucible Life

IN melting and holding furnaces of the types used for die-casting, crucible breakdown can add considerably to operating costs, and in certain circumstances may seriously interfere with production. One of the causes of crucible breakdown when charging with ingot is the tendency for the standard aluminium ingot to lie diagonally across the pot after being charged and before melting begins. In these conditions, the ingot begins to expand and exert pressure against the sides of the crucible sufficient to cause the walls to collapse.



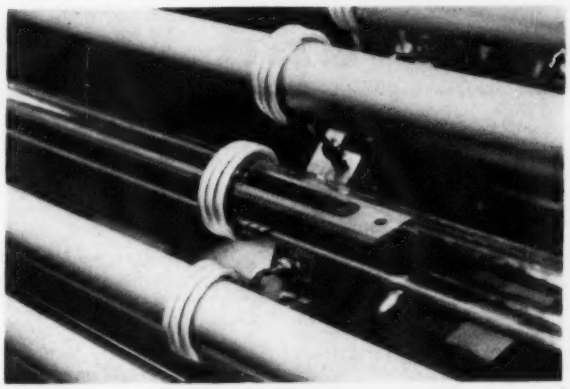
At the foundry of J. V. Murcott and Sons Ltd., the breaking hazard has almost been eliminated by the use of a longer ingot. Some 23-24 in. long, these ingots, designed with the co-operation of B.K.L. Alloys Ltd., are too long to slip into a diagonal position in either 100 lb or 300 lb. crucibles and, melting from the bottom upwards, their expansion presents no danger to the sides of the crucible. This long ingot also has the advantage of being more convenient for baling.

Above—Diagram showing disposition of a normal ingot in a crucible and (dotted) the long ingot designed to minimize pot breakage

Below—The lightweight argon welding torch marketed by Interlas

Right—The ElectriK Tel-O-Set two-wire measuring and control device with the top removed





Clear and opaque quartz tubes of the Lindberg multiple tube zone refiner, showing the induction coils mounted on the travelling yoke

Zone Refining on a Production Basis

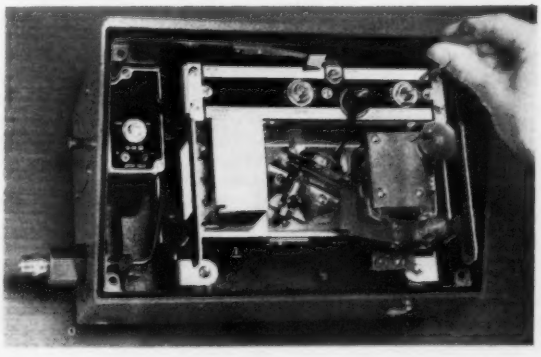
RAPID growth in the demand for single crystals, especially of semi-conductor materials, has led to the development of a multiple tube device by Lindberg Engineering Corporation. This multiple tube, horizontal zone refiner and crystal grower can be provided with 12 tubes of either clear or opaque quartz. The copper induction coils are water-cooled and mounted on a travelling yoke, as can be seen in the accompanying illustration.

Process Measurement and Control

AN electric measuring and control system with true two-wire D.C. transmission has been introduced by Honeywell Controls Limited. The equipment, which embodies modular principles, is known as the ElectriK Tel-O-Set system. Direct current transmission of the signal at 4-20 milliamps is used along a pair of wires that also carry the 42 volt D.C. power supply. There are no field power connections, and shielding of the transmission wires is not required.

Suitable for any of the usual industrial process control duties, the ElectriK Tel-O-Set system provides many modes of control, including "proportional + reset + rate action".

The basic system comprises a transmitter, a 5½ in. by 6 in. receiver-controller and a valve operator. The variety of standard alternative units is considerable and includes circular scale as well as strip chart controllers, simple recorders, millivolt-to-current transmitters, process-pressure-to-current transmitters, differential pressure-to-current transmitters, transducers for standard pneumatic-to-electric signals and vice versa.



Men and Metals

In succession to **Mr. M. J. S. Clapham,** who has joined the company's main board as an overseas director, **Mr. St. John de H. Elstub,** C.B.E., has been appointed chairman of the Metals Division of Imperial Chemical Industries Limited. He is



also chairman of Amal Limited and a director of Yorkshire Imperial Metals Limited. A member of the Institute of Metals and of the Council of the Institution of Mechanical Engineers, Mr. Elstub was appointed to the Engineering Board of Studies, National Council for Technological Awards, in 1958.

To fill the position vacated by Mr. St. J. Elstub, **Dr. William H. G. Lake,** O.B.E., Ph.D., has been appointed



joint managing director (technical) of the Metals Division of Imperial Chemical Industries Limited. He was appointed a director of the Division in 1957.

Chairman of W. J. Bush and Company, **Mr. E. L. Bush** has been appointed a director of Albright and Wilson (Mfg.) Limited.

It is announced that **Mr. F. G. Hawkings** has been appointed managing director, and **Mr. E. G. Smalley** deputy managing director, of Stone-Platt Industries.

A member company of Staveley Industries Limited, it has been announced by John Hill and Sons (Iron Founders) Limited that **Mr. G. E. Lunt** has been appointed a director of the company. Mr. Lunt is on the board of the parent company and is also managing director of Bradley and Foster Limited.

It has been announced that **Mr. F. G. Vincent** has been appointed managing director of Cox and Danks, a member of the Metal Industries group.

It is understood that **Mr. E. A. E. Schicht** has resigned from the board of Consolidated Tin Smelters.

Following the election of five members of committee at the annual general meeting of the Non-Ferrous Club in Birmingham, a further four members have now been co-opted in accordance with the rules. These members are: **Mr. R. L. Deutsch** (who will continue as secretary of the golf section), **Mr. P. Mould, Mr. G. E. Lewis** and **Mr. J. Freeman.**

Officers for the ensuing year of the Non-Ferrous Club have been announced as follows:—**Mr. P. Mould** (President), **Mr. B. Roberts** (chairman), **Mr. A. H. Bradley** (secretary), **Mr. A. E. Teasdale** (treasurer), and **Mr. G. E. Lewis** (press officer).

A number of changes have recently been made by Edgar Allen and Company Limited relating to directors and executive staff. These changes are as follows:—**Dr. Edwin Gregory** and **Mr. Bernard Blackwell Green,** directors, relinquish the full-time executive positions and appointments as chief metallurgist and general sales manager respectively. They remain in office as "non-executive" directors but will be available in a consultative capacity.

Executive responsibilities have been allocated to directors of Edgar Allen and Company Limited on a divisional and functional basis as follows:—**Mr. W. H. Higginbotham,** chairman of the board and chief executive; **Mr. J. Higginbotham,** divisional supervision of all commercial activities; **Mr. W. G. A. Jenkins,** divisional supervision of the foundry and steel melting, steel, saw, magnet, works engineering and ancillary operating services, and operational research departments; **Brigadier A. Levesley,** divisional supervision of marketing activities generally; **Mr. W. J. McBride,** divisional supervision of the engineering (including machining), trackwork, engineers' tools, development and research departments; **Mr. F. A. Ross,** secretary and chief accountant, with divisional supervision of administrative services in relation to employment generally.

Among other appointments made by Edgar Allen and Company Limited are those of **Mr. W. H. Everard** to be manager of the foundry and ancillary departments, **Mr. J. D. Studholme** to be manager of the engineering department, and **Mr. F. Haigh** to be sales manager.

The electroplating and metal finishing firm of A. T. Poeton and Son have announced the appointment of **Mr. Francis A. McAweeny** as a director and secretary of the company.

It is reported from Harshaw Chemicals Limited that **Mr. E. R. Thompson** has recently joined the sales department of the company.

In succession to **Mr. J. Ivan Spens,** who has retired from the board, **Sir Douglas Waring** has been appointed chairman of London Tin Corporation. He is also chairman of Tongkah Harbour Tin Dredging and Southern Kinta Consolidated.

A.S.T.M. Publications

AMONG recent publications of the American Society for Testing Materials are an index to the literature on X-ray spectrographic analysis and a new issue of the compilation of chemical compositions and rupture strengths of super strength alloys.

"The Index to the Literature on X-ray Spectrographic Analysis" is the first of a series of bibliographical surveys of the literature of X-ray spectrographic analysis. It covers 211 references for the years 1913 to 1957, although it is admittedly not an exhaustive compilation. It contains an author index as well as abstracts (mainly from Chemical Abstracts) and a subject index.

"The Compilation of Chemical Compositions and Rupture Strengths of Super-Strength Alloys" was first issued in 1955, and this is the second revision. All known alloys are included. Those no longer in commercial production, as well as experimental alloys, are so indicated. As a matter of general interest, a list has been added to this edition of the Aeronautical Material Specifications (AMS) of the Society of Automotive Engineers, which cover the various alloys identified by trade name. Both the above books are obtainable from A.S.T.M. Headquarters, 1916 Race Street, Philadelphia 3, Pa., at $1.50 each.

A series of over 200 definitions relating to electroplating of metals has been prepared for publication by A.S.T.M. Committee B-8 on Electrodeposited Metallic Coatings and Related Finishes. A specification for multi-layer (duplex) electrodeposited nickel coatings has also been prepared to permit standardization of these coatings for use in outdoor surfaces.

MELTING AND CASTING FOR VARIOUS PARTS IN REACTIVE METALS

Titanium Casting Technology

By S. L. AUSMUS, F. W. WOOD and R. A. BEALL

(*Concluded from* METAL INDUSTRY, 31 *March* 1961)

PRACTICAL casting techniques have been developed, but there are several areas of potential improvement. The need has been shown for further development of mould designs and materials or other changes leading to reduced costs, improved casting soundness, and a wider range of process application. Also, the use of vacuum techniques has not been fully exploited for maximum improvement of product quality. Progress toward these objectives is continuing, but there is a real need for a clearer understanding of process control and the influence of various operating parameters. Of special interest are variations in the yield of metal (per cent of charge poured), the distribution of heat, metal temperatures, and melting rates as functions of arc current, pressure, alloy composition, and casting sizes.

Two separate series of zirconium casting heats were made to study the influence of electrode diameter on the yield of metal. The first series consisted of three heats, all without benefit of initial skulls, in a 9½ in. diameter ladle, at nominal currents of 8,000 amp., and at nominal pressures of 100 to 200μ. The only deliberate variable between heats was the electrode diameter. As an extra precaution, all electrodes were fabricated from the same ingot stock to minimize variation of metal composition. Table III shows the results. A second series of three heats followed, using the same procedure, except that the ladle was 8½ in. in diameter, pressures were more nearly 400μ, and the electrode sizes were smaller. Table IV tabulates the results. The variation of the yields in each series has no significant order in relation to electrode size. The minor differences observed are no more than might be expected to result from such things as cooling irregularities. However, it is not standard practice to generate a new skull in each heat, as was done in the experiments. Accordingly, a conclusion that electrode size has no bearing on yield must be qualified by the admission that when a skull is retained through a series of successive heats its weight usually increases slightly to some equilibrium value over the first several melts. This weight increase is principally a build-up at the upper rim of the skull, and it is suspected that the ultimate build-up is greater for smaller electrodes.

A larger series of experimental heats with titanium alloys furnished information on yields, metal temperatures, melting rates, and mould reactions. This series included six levels of arc current, three distinct ranges of pressure, three ladle sizes, and four alloy compositions. Each of the various water-cooling loops associated with the casting furnace was equipped with a flowmeter and iron-constantan thermocouples for continuous recording of coolant volume and temperature. These data were used to calculate the relative distribution of heat to the various furnace components as a function of time. Strip-chart records of current, potential and time supplied a total energy input figure for each heat, and this was proportioned and assigned in accordance with the heat distribution derived from the volume and temperature of cooling water. Average molar heat contents and metal temperatures were deduced from the partition of energy between the molten and solid portions of the charge. As standard practice, weights were obtained that allowed the calculation of metal yields and average melting rates. Each pour was made into a network of cubical mould cavities ranging in size from 1 to 8 in. Most moulds were of machined graphite, but in several instances sizes up to 4 in. were duplicated with mould components of rammed graphite furnished by Frankford Arsenal. Thus, direct comparison was possible between the various sizes and between the two mould materials. Rammed mould materials are, however, being constantly improved.

The choice of method for temperature estimation may be criticized, but the method was selected because the temperatures are too high for conventional probe measurements, and optical or radiation pyrometry is complicated by ionized vapours and reflection of an electrode image from the molten pool surface. In addition, investigators decided that an average temperature has more significance than a localized temperature.

Figs. 14 and 15 present some effects of arc-current variation. These graphs are associated with the operating data of Table V. Although the efficiency of operation reached a maximum at some optimum current near 10,000 amp., the temperature of the molten metal continued to increase at higher currents.

Arc current is also a major factor in determining melting rates. That the melting rate is directly proportional to arc current has been recognized by those who engage in D.C. arc-welding with a consumable rod[7] and in production of simple ingots by consumable electrode arc melting. This is also true of consumable electrode arc casting, but care must be exercised in defining melting rate. In arc melting ingots, where a skull is not formed, the melting rate is the same as the rate of electrode consumption. Skulls are involved in arc casting, and researchers found that any loss of weight by a skull must be added to electrode consumption to yield a melting rate proportional to arc current. If a skull gains weight, the increase represents metal acquired from the electrode and is already included in the electrode consumption rate. The ratio of melting rate to current in the experiments under discussion was about 1·2 lb/min/kilo-amps. No ordered dependence of melting rates, temperatures, or operating efficiencies on arc power were discovered. The influence of current was independent of electrical potential.

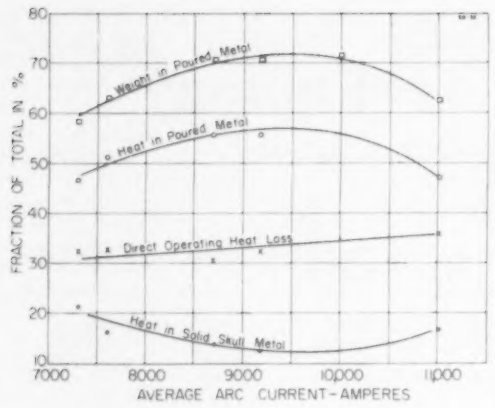
Ladles of different sizes were used

TABLE III—METAL YIELD AS FUNCTION OF ELECTRODE DIAMETER, 75-LB. HEATS

Heat No.	Electrode diameter in.	Residual skull weight lb.	Weight poured lb.	Yield per cent
SA 11366	8	39·2	75·0	65·5
SA 11367	6	34·0	75·0	68·8
SA 11370	4	34·4	71·0	67·3

TABLE IV—METAL YIELD AS FUNCTION OF ELECTRODE DIAMETER, 40-LB. HEATS

Heat No.	Electrode diameter in.	Residual skull weight lb.	Weight poured lb.	Yield per cent
SA 11557	6	15·9	40·1	71·6
SA 11558	4⅜	13·2	40·6	75·4
SA 11559	3	13·2	40·6	75·4

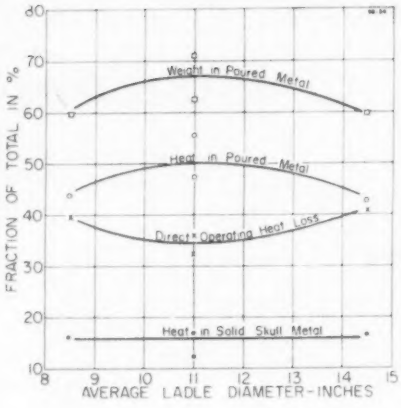


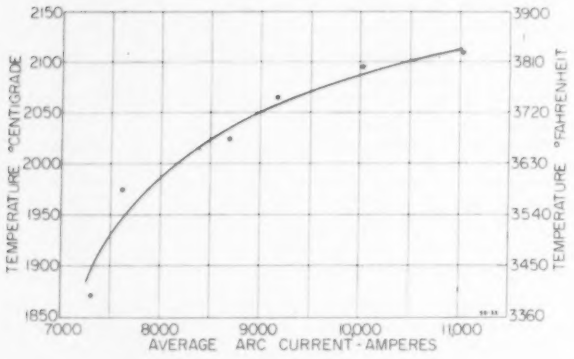
Left: Fig. 14—Heat distribution and metal yield as functions of arc current

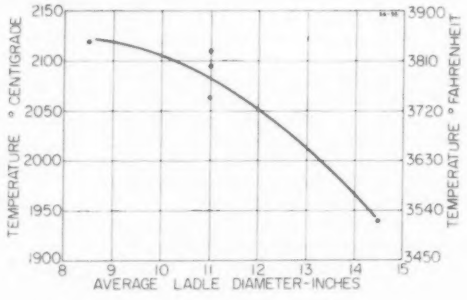
Below left: Fig. 15—Temperature of poured metal as function of arc current

Right: Fig. 16—Heat distribution and metal yield as functions of ladle diameter

Below right: Fig. 17—Temperature of poured metal as function of ladle diameter







with results shown in Figs. 16 and 17. The diameter of each ladle was 1 in. smaller at the bottom than at the top. The resulting taper facilitated removal of residual skulls but necessitates the use of an average diameter as an index of size. The scatter of data corresponding to the 11 in. ladle size is disturbing at first glance, but more detailed inspection reveals that the spread of values reflects the effect of uncontrollable arc-current variations. Since the ladle size can be fixed rigidly, the scatter did not appear in Figs. 14 and 15, but since arc current cannot be precisely controlled, its variation must be taken into account in evaluating Figs. 16 and 17. Within the range of conditions used in the tests with various arc currents, pressures and ladle sizes, the relation between current and ladle size with regard to molten-metal temperature can be expressed by the empirical quadratic approximation:

$$T = 430(1 + 0{\cdot}51\,I - 0{\cdot}231\,I^2)(1 + 0{\cdot}0655\,d - 0{\cdot}003367\,d^2),$$

where T is average temperature in °C., I is arc current in kilo-amperes, and d is the mean ladle diameter in inches. A variety of other empirical approximations could have been used. The agreement between values as calculated above and the calorimetrically measured temperatures are shown in Table V. The most serious disagreements occur at currents below 8,000 amp and high pressures.

Attempts to approximate metal yields with equations of similar form have been unsuccessful. Unfortunately, the nature of the relationship between arc current and ladle diameter is more complex when yields are considered, and it appears that a logarithmic or exponential term may be involved. In any case, the utility of such empirical approximations is limited. There is a real need for a practical, but simplified model of the molten pool during arc melting that will allow a theoretical deduction of equations for temperature and volume.

On the basis of earlier studies,[8] there is little doubt that furnace pressure constitutes a third interacting variable, but variable-pressure-series results indicate that the effect is subordinate to the influence of current and ladle size and less significant than the estimated error of temperature measurement. Thus, to define the role of pressure, more precise methods of arc-current control and of temperature measurement would have to be devised.

Probably the most significant facts that may be inferred from the data for the various alloys that were available are that molten-metal temperatures were generally higher and operating efficiencies were lower for alloys containing manganese. On the basis of previous routine experience, the lower efficiencies were expected, but investigators had assumed that this was caused by an excessive loss of heat by vaporization of manganese. The existence of higher temperatures and the pressure levels maintained completely contradict this notion. Instead, it now appears that the explanation of lower efficiencies for manganese alloys goes much deeper

TABLE V—COMPARISON OF MEASURED AND CALCULATED VALUES OF AVERAGE MOLTEN-METAL TEMPERATURES

Heat No.	T_m, measured °C.	T_c, calculated °C.	$\frac{T_m - T_c}{T_c} \times 100$ per cent
SA 17299[1]	1870	1922	−2·71
SA 17653[2]	1940	1927	+0·67
SA 17285[1]	1975	1950	+1·28
SA 17230	2025	2029	−0·20
SA 17469	2065	2055	+0·49
SA 17540[3]	2070	2098	−1·34
SA 17397	2095	2085	+0·47
SA 17604	2110	2098	+0·57
SA 17563[3]	2115	2100	+0·71
SA 17774[4]	2120	2107	+0·62

[1] *Low current* [2] *Large ladle* [3] *High pressure* [4] *Small ladle*

and involves a basic influence of manganese on the arc-discharge mechanisms, whereby the heat directly received by the arc cathode decreases, and that received directly by the anode (in this instance the molten pool) increases.

The temperature of skull metal was remarkably uniform throughout, regardless of operating conditions. Variations were random and could not be related to operating conditions. Values ranged from 1,385°C. to 1,650°C. and averaged 1,500°C. The one 1,650°C. value was obtained with commercially pure titanium and is probably too high, since the melting point is only 1,660°C. The estimated error for all reported metal temperatures is ±50°C.

The similarity between the fraction of the total charge poured and the fraction of total heat contained by molten metal may be noted in Figs. 14 and 16. Although the similarity seems perfectly logical, it could not be anticipated. The heat content of molten metal certainly must depend to some extent on the volume or mass of molten metal, but not necessarily on the fraction of total charge represented by that mass.

The heat lost during arc operation and not appearing in either cast metal or the residual skull varied widely from about 30 to 70 per cent of the total heat input. The manner in which direct heat losses were dissipated was fairly consistent, however. Of this direct loss, 80 to 88 per cent was included in the heat content of cooling water from the ladle. Another 10 to 20 per cent represented heat generated in water-cooled electrode components, including friction brushes used to apply power to the stinger shaft. Less than 1 per cent appeared as miscellaneous losses through furnace walls.

Unfortunately, complete evaluation of the castings produced as part of the experimentation described above is laborious and time consuming. Consequently, full information is not yet available, but results of a cursory analysis of reactions between molten metal and graphite moulds indicate that the only clear implication to be drawn is that the 1 in. moulds were more susceptible to attack by molten metal than the larger sizes. It is believed that this is a consequence of a washing action accentuated by the small dimensions. In larger moulds, the force of metal flowing in is dissipated over surface areas that are larger and more remote from the point of metal entry. Results show that the surfaces of cubes cast in rammed graphite moulds are sufficiently contaminated to have low corrosion resistance. However, sand blasting and pickling of such castings should readily expose corrosion-resistant metal. Typical analyses for carbon in the melting stock used to produce the cubes were between 100 and 200 p.p.m.

References

[7] F. L. Wilson, G. E. Clausen and C. E. Jackson; *Weld. Jour.*, 1956, **35**, 1.

[8] R. A. Beall, J. O. Borg and F. W. Wood; Bureau of Mines Rept. of Investigations 5144, 1955.

High Temperature Diffusion Furnace

NEW high temperature diffusion furnaces designed to meet exacting temperature requirements, have been installed in the Transistor Division of Standard Telephone and Cables Ltd. The furnaces were supplied by Royce Electric Furnaces Ltd. and are used in the production of high frequency, double diffused silicon transistors.

Incorporating a floor standing cabinet for all the electrical gear, the furnaces are self-contained units suitable for use with nitrogen, oxygen and hydrogen atmospheres. They are designed to take work tubes of either impervious fused alumina or transparent silica having an inner diameter of 2 in.

Each furnace has both a preheat and a high temperature section, the preheat section being mounted on wheels so that it can be moved to and from the main chamber and locked in the required position.

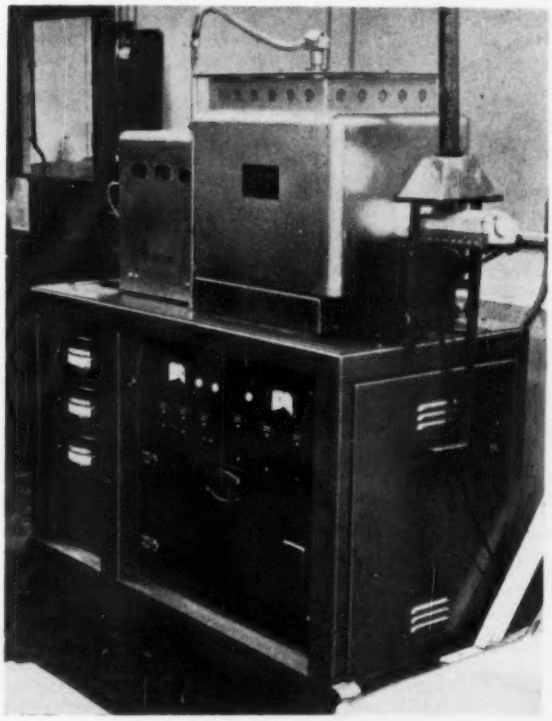
The preheat section has a heated length of 12 in. arranged in three zones and providing a range of temperatures from 200°C. to 1,000°C. It comprises a high grade refractory tube housed in a refractory lined chamber and carrying three separate heater windings of heavy gauge, nickel chromium wire.

The high temperature section has a refractory tube in a brick-lined chamber of high temperature refractory backed by thermal insulation. The heater length of 15 in. is controlled in one zone and provides any temperature required between 950°C. and 1,300°C. Heating elements are of silicon carbide and are positioned vertically along the side walls of the chamber.

The temperatures of the two sections are independently controlled and, within the specified temperature ranges, any desired temperature can be maintained in either section irrespective of the operating temperature of the other section. Automatic temperature control is by indicating controllers, two instruments controlling the preheat section and a third, an anticipatory controller, operating the high temperature section.

A feature of the furnaces is the provision of even temperature zones, one 2 in. long in the preheat section, the other 3 in. long in the high temperature section. In these zones, any specified temperature within their respective ranges can be maintained with a uniformity and a stability with time of ±2°C. A fall in temperature cannot occur between these two zones.

The furnaces are each rated at 7¼ kW. They are 6 ft. long by 2 ft. 6 in. wide and have a working height of approximately 4 ft.



Royce high temperature diffusion furnace in the Transistor Division of Standard Telephones & Cables Ltd.

Industrial News

Home and Overseas

New Factory

A contract to build a new factory, on a 20-acre site at Hednesford, Staffs., has recently been approved in principle by the **Fafnir Bearing Company Ltd.** This new building, which will initially cover a total of 60,000 ft², is to rehouse the Hednesford workers with the most modern type of factory building. Operations are to commence immediately and it is expected that the building will be ready for use by November of this year.

Spanish Lead Tax Reduced

In an official bulletin issued recently in Madrid, the excise tax on imports of lead are reduced from about 12 per cent to 5 per cent during the first six months of this present year. The measure followed the temporary suspension of the foundry and sales taxes on lead, also operative during these same six months. Both measures aim at lowering lead prices to stimulate consumption in the home market.

Malayan Tin Mining

Production of tin concentrates in Malaya in February was 90,364 piculs, containing 4,065 tons of metal based on an assay value of 75·58 per cent, according to the Malayan Mining Statistics. This compared with the January figures of 101,444 piculs, 4,565 tons, and 75·60 per cent respectively. The average daily rate of production in February was 3,227 piculs of tin concentrates, compared with 3,272 piculs previously.

Deliveries of tin concentrates from mines to smelters were 89,729 piculs (99,340 previously), containing 4,037 tons of metal based on an assay of 75·58 per cent. At the end of the month, there were 70 dredges, 480 gravel-pump mines and 50 other tin mines in operation, making a total of 600 active tin mines, against a total of 603 in the previous month.

At Moscow Trade Fair

A British exhibit of much interest at the Trade Fair being held in Moscow next month will be that of **Telcon Metals Limited,** who will be displaying special metals and products and their various applications. In addition to examples of high permeability alloys and nickel-iron compositions, the company will also exhibit a range of thermostatic bimetals, and a selection of glass-to-metal sealing alloys.

New Sales Office

An announcement from **Thomas Bolton and Sons Ltd.** is to the effect that their Birmingham sales office has now been transferred to 7 Market Street, Lichfield, Staffs., with the telephone number of Lichfield 3632. This office will now serve the North and South Midlands sales areas, and the following sales representatives may be contacted there:—Mr. F. W. Wolliscroft, Mr. C. R. H. Johnson and Mr. J. Middleton.

The closure of the Birmingham office severs a link with the past, as the Bolton business was founded in Birmingham in 1783 by Richard Bolton (1750-1812), who is described as "of Dudley, Worcester, merchant and manufacturer".

In 1825, Thomas Bolton, son of Richard, built a works in Broad Street, Birmingham, where in the (18-) forties, "brass and copper wire, rolled metals, locomotive engine and other tubing" were manufactured. Activity continued on that site until 1912, when the works moved to Froghall, near Stoke-on-Trent.

Radioactive Hazards

Requirements for the protection of workers against ionizing radiations and other hazards from radioactive substances are laid down in a statutory draft of Regulations published by the Ministry of Labour on Thursday of last week.

The Regulations lay down maximum permissible radiation doses which may be received by employed persons. These are based on the recommendations of the International Committee on Radiological Protection, and have received the support of the Medical Research Council. The Regulations provide for reliance to be placed wherever possible on working arrangements that provide intrinsic safety, and for the instruction of workers concerned about the hazards involved and the precautions to be taken. Provision is also made for medical supervision.

The Ionising Radiations (Sealed Sources) Regulations, 1961, are published by H.M. Stationery Office, price 9d. net.

Works Engineers' Meetings

During 1960, **Imperial Chemical Industries Limited** organized a number of meetings at which technical Papers were presented by I.C.I. personnel in provincial centres. The meetings were attended by works engineers and prompted some valuable discussions. The company therefore decided to extend the range of lectures during 1961, and the first of these was held in Bristol on March 20 last.

The next meeting will be held in Cardiff on April 11, and further meetings are to be held as follows: Derby (April 20), Liverpool (April 26), Manchester (May 2), Leeds (May 10), and Glasgow (May 31).

Copper in Sweden

News from Stockholm is to the effect that A.B. Svenska Metallverken has reported the expansion of its copper wire mill in Vaesteraas. With a new automatic installation built, production has been increased from 25,000 to 40,000 tons a year, it was stated.

Alumina Plant for British Guiana

Important new facilities for the manufacture of alumina in British Guiana were officially inaugurated last week by Dr. Cheddi Jagan, Minister of Trade and Industry. The occasion was the first shipment of alumina from the Demerara Bauxite Company Limited's 230,000-tons-per-year alumina plant at Mackenzie, 60 miles up the Demerara River from the Atlantic and accessible to sea-going freighters.

The Demerara Bauxite Company Ltd. is one of several bauxite mining companies which supply Aluminium Limited's smelters in Canada and other countries with the basic raw material. The coming into production of the alumina plant in British Guiana completes Aluminium Limited's development of a raw material base sufficient to support an eventual aluminium smelter capacity in Canada of the order of one million tons per annum.

Greater Stocking Facilities

Warehouse space, for some time at a premium in the West Bromwich factory of **Geo. Salter and Co. Ltd.,** will soon cease to be a problem, for the company now has local authority approval to build an extension, the overall cost of which will be £100,000. The new warehouse will be situated on the company's North Works site, adjacent to the factory producing spring balances and retainers—both of which involve holding large stocks to meet urgent demands from home and overseas markets.

The two storey, reinforced concrete building will be fully equipped for mechanical handling and palletized storage of products on the first floor, with case making and packing and despatch services, as well as covered-in loading decks at ground level. Access will be via Overend Street and this will relieve some of the congestion from West Bromwich High Street. Clearance of the site, involving demolition of some old Salter production departments and dwelling houses, has already commenced, and it is expected that the new premises will be completed and in service early in 1962.

Change of Address

At the present time **Harshaw Chemicals Limited** is engaged in the erection of a modern factory at Daventry, and it is hoped that production at the new premises will commence later this year. In the meantime, the company's sales department has secured temporary accommodation at London Road, Daventry (telephone Daventry 395), and all communications regarding orders, deliveries, etc., should be sent to that address.

It will, however, be some time before laboratory services are available at Daventry, and customers are notified that samples should be sent direct to Waltham Cross.

Die-Casting

On Monday of last week, the fourth and last of the series of evening discussion meetings being held by the **Zinc Alloy Die Casters' Association** this season took place at the Great Western Royal Hotel, in London. The meeting was attended by about 100 representatives from member firms, and the chairman was Mr. Reg Turner, of Metal Castings Ltd. The subject was "Vacuum Die-Casting" and the discussion was opened by Mr. H. K. Barton, who talked on the various ways of applying vacuum to the die cavity, condensing the Paper he gave at Detroit last autumn.

After the talk, the discussion was thrown open, and questions raised on the practical aspects of vacuum die-casting were answered by Mr. Barton, Mr. Millard, Mr. Pollock and Mr. Adams. As at previous meetings, speakers showed themselves very interested in new developments, but not all were convinced of the utility of the process as applied to general commercial casting, though its value in

making very large thin castings was undisputed.

In view of the interest aroused by the series of meetings, a further season of similar meetings will be organized by the Association next autumn.

A Removal

Due to continued expansion of business, larger offices are required by **Plus-Gas Company Ltd.,** and after tomorrow (April 8) the head office of the company will be at Trevor House, 100 Brompton Road, London, S.W.3, with the telephone number of Knightsbridge 0425/8.

Aluminium Plant for Malaya

According to news from New York, Aluminium Limited have announced plans to build the first aluminium rolling mill in Malaya through the formation of a company in the Federation of Malaya called Alcan Malayan Aluminium Company Limited. The new mill will produce aluminium sheet, circles and building sheet.

Initially, the subsidiary will be wholly owned by Aluminium Limited, which will finance the enterprise and provide the technological know-how. Malayan personnel will operate the plant, and steps will be taken to train Malayan managerial staff. The plant will be located at Petaling, Java, near Kuala Lumpur, and construction is expected to start immediately. The estimated cost of the enterprise is over $1,300,000.

Ultrasonic Cleaning Plant

A cabinet model of the ULV1 ultrasonic cleaning plant has now been introduced by **Imperial Chemical Industries** General Chemicals Division. Like the standard version, it is suitable for cleaning metal, glass and ceramic articles where, as well as complete degreasing in trichloroethylene, freedom from fine solid matter is required. Unlike the standard model, though, the pipework and the Dawe ultrasonic generator are enclosed in an attractive cabinet, which has a Formica top available in a range of colours. It is of especial value in those sections of industry requiring ultrasonic cleaning plants which not only clean efficiently but which can be used in "clean air rooms".

Special-Purpose Greases

Two new greases, one No-Melt and the other calcium-based, are announced as an extension of their present range by **Bardahl Products Ltd.** No-Melt grease is designed for use at unusually high temperatures and is capable of staying on bearings at temperatures up to 1,000°F. (538°C.). There is no drop point for this type of grease.

The new water repellent grease which is being added to the range is calcium-soap based and intended for low temperature work where moisture or water has proved excessive for other greases.

Wire Stripper

Recent news from **Roto-Finish Limited** concerns the introduction of a new product, "Wire Stripper 493", for stripping baked enamel insulation and synthetic coatings from wire and from vertical or other large surfaces. This process is particularly suitable for use on, for example, commutators, motor windings or any insulated electrical windings.

The method of use is said to be simple. The stripper is applied to the coating to be removed, which is left until it lifts, and then wiped clean. Roto-Finish "493 Diluent" is used to adjust the viscosity of the 493 stripper when very thin wires are being stripped or when the 493 stripper becomes too viscous, due to long exposure. This 493 stripper is stated to work at an extremely fast rate.

U.K. Metal Stocks

Stocks of refined tin in London Metal Exchange official warehouses at the end of last week rose one ton to 10,264 tons, comprising London 4,289, Liverpool 3,882, and Hull 2,093 tons.

Copper stocks rose 122 tons to 14,972, distributed as follows:—London 625, Liverpool 12,272, Birmingham 100, Manchester 1,925, and Hull 50 tons.

Lead duty-free stocks rose 450 tons to 7,464 tons, while in-bond stocks fell 24 tons to 3,843 tons. All supplies were in London.

Zinc duty-free stocks rose 436 tons to 3,976 tons, while in-bond stocks were unchanged at 250 tons, comprising London duty-free 2,247 tons and in-bond 250 tons, Liverpool duty-free 1,699 tons, and Glasgow duty-free 30 tons.

Malayan Tin Shipments

Tin shipments from Penang in March amounted to 6,500¾ tons, according to the Straits Trading Company. They comprised U.K. options 70 tons, United States 2,163¾, Continent 2,068, Canada 230, Japan 996, Pacific 29, India 692½, South America 164, Africa 20, Australasia 41½, and Middle East 26 tons. Shipments from Singapore in March totalled 525½ tons, comprising United States 100, Continent 349½, Canada 25, Pacific 34, India 6¼, South America 2, and Middle East 9 tons.

German Aluminium Output

West Germany produced 12,681 tons of pig aluminium in February, according to provisional figures issued from official sources. Final January figures show that production then amounted to 14,131 tons.

Production of pure aluminium in February was 2,229 tons, against 1,895 tons in January, and of aluminium alloys, 9,718 tons against 10,404 tons previously. Semi-manufactureds from aluminium and aluminium alloys in February amounted to 19,302 tons, against 20,951 tons in January.

Additional Sales Strength

It has been announced by **Thos. P. Headland Ltd.** that they have increased their sales force by the appointment of two additional representatives in Essex and the London postal districts, North and East. Mr. B. G. Barnes will cover the area specializing in machine tools and accessories, while Mr. T. Cusselle will cover the same area specializing in all types of gas and electric welding equipment.



The cabinet model of the ULV1 ultrasonic cleaning plant recently introduced by the General Chemicals Division, I.C.I.

Forthcoming Meetings

April 10—Institute of British Foundrymen. Sheffield Branch. Technical College, Pond Street, Sheffield. "Cost Control in the Foundry". D. A. Crooks. 7 p.m.

April 11—Institution of Works Managers. Birmingham Branch. College of Technology, Gosta Green, Birmingham. "Recent Developments in Machine Tools." C. A. Sparks. 7 p.m.

April 12 — Leeds Metallurgical Society. University Staff House, University Road, Leeds. "Some Aspects of the Metallurgy of Fasteners." R. J. Allsop. 6.30 p.m.

April 13 — East Midlands Metallurgical Society. Derby and District College of Art. "Recent Work on Cold Forming and Extrusion." N. S. Angus. 7.30 p.m.

April 13—Institution of Plant Engineers. North-East Branch. Roadway House, Oxford Street, Newcastle upon Tyne. "Modern Welding Processes." J. A. Lucey. 7 p.m.

Metal Market News

CONSIDERING that last week's trading on the Metal Exchange covered a period of only three-and-a-half days, the turnovers were very satisfactory and probably, pro rata, not much below average. So far as the price trend was concerned, copper and lead lost ground, the former falling on account of a settlement of the Chilean dock strike, and the latter due to some disappointment that the decisions reached in the previous week at Mexico City were not more helpful. In effect, the arrangement is for output of lead from the consenting countries this year to be reduced to a level 2 per cent below the estimated consumption figure. On top of this, it is hoped to arrange for the United States to absorb on a barter basis for stockpiling an undisclosed tonnage from exporting countries. Russia is, of course, an unknown and unpredictable factor in all this, and, moreover, however effective these plans may be in coping with the excess of current production, there remain very large stocks on hand in certain directions. However, it is something that action is planned, and at least what has been decided ought to go some way towards putting a brake on the decline in the lead quotation. Nothing, apparently, was agreed about zinc, which, however, may well be affected to some extent, for the two metals are mined together in many districts.

Metal Exchange warehouse stocks of lead were reduced by 25 tons to 10,881 tons, while the zinc tonnage advanced by 232 tons to 3,790 tons. Other changes announced were a rise in tin stocks of 273 tons to 10,263 tons, and a fall of 415 tons in copper to 14,850 tons. It is satisfactory to note that a contango rules in copper, tin and lead, while in zinc the backwardation at the close of business on Friday was no more than 5s. Moreover, with stocks of zinc showing a rising tendency, it is difficult to believe that a contango will not be achieved before long. As is usual, the approach of the Easter holiday has slowed down business with consumers, but, all things considered, demand has been reasonably good. Not unnaturally, users have been inclined to hold off in view of the downward trend of copper and lead, but after Easter more interest may well be shown, especially if a small rally should occur. Unfortunately, the situation in the United States does not show any real sign of improvement, and in some quarters it is felt that the bottom of the depression there has not yet been reached.

In standard copper, some 7,000 tons changed hands up to Thursday's mid-day market, when the Exchange closed its doors for the week. At the close, cash stood at £224 15s. 0d., a loss of 35s. on the week, while three months lost 25s. to £226 15s. 0d. No change was made in the U.S. prices, but scrap copper was reduced by 25 points. It seems unlikely that any embarrassment will be caused to consumers in Europe by the Chilean dock strike. In tin, the turnover was 560 tons, the close showing cash 10s. down at £825, with three months £1 up at £828. The turnover in lead was 7,200 tons, cash being 25s. down at £65 15s. 0d., and three months 30s. lower on balance at £66 17s. 6d. Cash zinc lost 10s. to £83 15s. 0d., and three months 2s. 6d. to £83 10s. 0d. The turnover was 5,700 tons.

Birmingham

Following the Easter holiday, the market for metals in the Birmingham area is returning to normal. The outlook for the second quarter is bright; although consumers are not ordering raw materials on any heavy scale for forward consumption, output is being taken up. The motor trade has improved considerably during the last few weeks, and this is reflected in a larger consumption of metal sheet, stampings and pressings. Sales of domestic hardware are expanding. The building trade continues very active and there is still a good flow of new contracts in civil and general engineering.

The iron and steel industry continues well employed. More sheets are required by the motor trade and there is a strong market for constructional steel. Foundries are well situated for work over the next few weeks. In the re-rolling trade, good business is being done in small bars and sections. The position in regard to shortage of labour is easier. There is a steady flow of pig iron from the furnaces. Iron required for the production of steel is in active demand, and there is a bigger demand for foundry grades.

New York

Tin consumption in the United States increased 21 per cent in January 1961, according to the Bureau of Mines, United States Department of the Interior. Tin used during the month totalled 5,965 long tons, and comprised 3,680 of primary pig tin and 2,285 of secondary and imported tin-base alloys. December consumption of tin was 4,915 long tons, 2,845 of primary and 2,070 of secondary and imported tin-base alloys.

In January, brass mills used 100 long tons of tin (65 of primary pig tin and 35 of secondary pig tin and scrap). December consumption was 90 long tons, comprising 65 of primary pig tin and 25 of secondary. Brass mills' stocks of pig tin increased 20 tons and totalled 130 tons at the end of January.

Total United States industry tin stocks declined (for the first time since July 1960) from 40,135 long tons on January 1 to 38,175 tons on January 31. Excluding tin in process and afloat, stocks in the United States stood at 23,935 long tons on January 31, 1961. At the January rate of consumption, this tonnage was sufficient for nearly seven months. Tin metal afloat to the United States was 2,195 tons at the end of January, a decrease of 795 tons.

Metallic tin imports in January dropped 34 per cent and totalled 2,058 long tons, the lowest since February 1952. Receipts of tin-in-concentrates were 802 long tons in January (1,176 in December). Total secondary tin recovered in all forms was 1,750 long tons in January compared with 1,725 tons in December.

Federated Metals Division of American Smelting and Refining Company has increased prices for brass and bronze ingots by three-quarters of a cent to one cent a lb. A spokesman for ASARCO said that the increase was not based on an improved demand for the company's ingots — instead, the spokesman added, it resulted from foreign purchases of ingot-making grades of scrap by foreign sources, primarily Japanese. This had led to a tightening of available scrap and a resulting increase in scrap prices far beyond levels consistent with the selling price of the ingot.

Italy

It has been announced in Brussels that the Commission of the European Economic Community has decided, in principle, to authorize the Italian Government to adopt safeguard measures for a number of products, including unwrought lead and zinc spelter. These safeguard measures provide protection for the Italian market *vis-à-vis* other member countries of the E.E.C. as well as non-member countries. The protection granted extends, in certain cases, to the postponement of approximation to the common external tariff. Its effect is now more than to confirm the *status quo*.

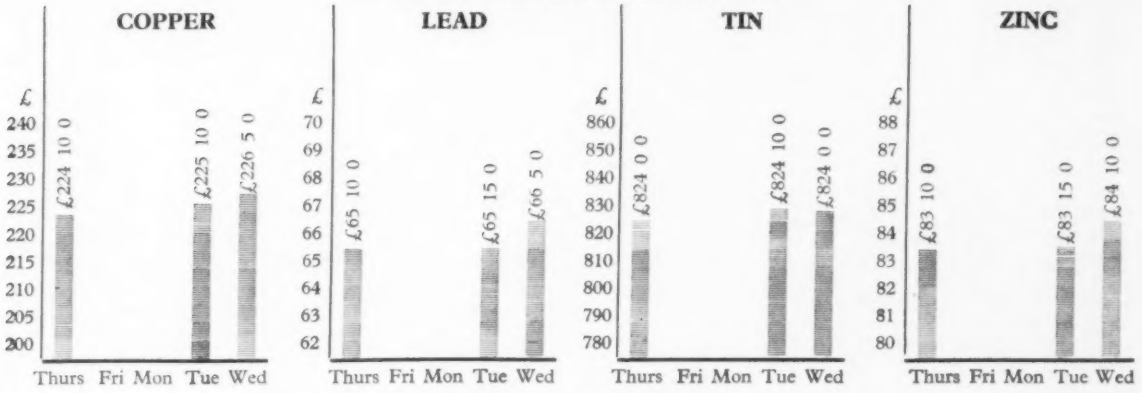
In return, the Italian Government will lay before the Commission a programme of reorganization in respect of several of these products and submit an annual progress report on the execution of this programme, so that a decision may be taken at the appropriate time on the re-opening of the Italian market.

The Italian Government will have to ensure that the temporary retention of the customs duties in question does not give an undue advantage to the Italian producers using the protected commodities.

Non-Ferrous Metal Prices

London Metal Exchange

Thursday 30 March to Wednesday 5 April 1961



Primary Metals

All prices quoted are those available at 2 p.m. 5/4/61

		£	s.	d.
Aluminium Ingots	ton	186	0	0
Antimony 99·6%	„	237	10	0
Antimony Metal 99%	„	230	0	0
Antimony Oxide Commercial	„	194	10	0
Antimony White Oxide	„	196	0	0
Arsenic	„	400	0	0
Bismuth 99·95%	lb.		16	0
Cadmium 99·9%	„		11	0
Calcium	„	2	0	0
Cerium 99%	„	15	0	0
Chromium	„		6	11
Cobalt	„		12	0
Columbite per unit			8	10	0
Copper H.C. Electro	ton	226	5	0
Fire Refined 99·70%	„	225	0	0
Fire Refined 99·50%	„	224	0	0

		£	s.	d.
Copper Sulphate	ton	77	0	0
Germanium	grm.		—	
Gold	oz.	12	10	9
Indium	„		10	0
Iridium	„	24	0	0
Lanthanum	grm.		15	0
Lead English	ton	66	5	0
Magnesium Ingots	lb.			
99·8%	„		2	2½
99·9+%	„		2	3
Notched Bar	„		2	9½
Powder Grade 4	„		5	6
Alloy Ingot, AZ91X		1	11½-2	1¼
Manganese Metal	ton	280	0	0
Mercury	flask	69	0	0
Molybdenum	lb.	1	10	0
Nickel	ton	600	0	0
F. Shot	lb.		5	5
F. Ingot	„		5	6
Osmium	oz.	20	0	0
Osmiridium	„		—	

		£	s.	d.
Palladium	oz.	9	0	0
Platinum	„	30	5	0
Rhodium	„	46	0	0
Ruthenium	„	16	0	0
Selenium	lb.	2	6	6
Silicon 98%	ton	122	0	0
Silver Spot Bars	oz.		6	7⅛
Tellurium Sticks	lb.	2	0	0
Tin	ton	824	0	0
***Zinc**				
Electrolytic	ton		—	
Min 99·99%	„		—	
Virgin Min 98%	„	84	5	7½
Dust 95/97%	„	125	0	0
Dust 98/99%	„	131	0	0
Granulated 99+%	„	109	5	7½
Granulated 99·99+%	„	124	8	9

**Duty and Carriage to customers' works for buyers' account.*

Foreign Quotations

Latest available quotations for non-ferrous metals with approximate sterling equivalents based on current exchange rates

	Belgium fr/kg≏£/ton	**Canada** c/lb≏£/ton	**France** fr/kg≏£/ton	**Italy** lire/kg≏£/ton	**Switzerland** fr/kg≏£/ton	**United States** c/lb≏£/ton
Aluminium		26.00 210 12	2.43 179 11	370 216 1	2.50 210 5	26.00 207 4
Antimony 99.0			2.30 170 0	500 292 0		29.00 231 2
Cadmium			15.75 1,069 0			150.00 1,195 10
Copper						
Crude				430 251 2		
Wire bars 99.9						
Electrolytic	31.00 226 11	27.50 222 15	3.15 232 15		2.75 231 5	29.00 231 6
Lead		10.00 81 0	.96 70 18	164 96 15	.78 65 11	11.00 87 13
Magnesium						
Nickel		70.00 567 0	9.00 665 2	1,180 689 2	7.50 630 15	74.00 589 15
Tin	113.75 831 7		11.61 843 3	1,530 893 10	9.65 811 11	103.87 827 16
Zinc						
Prime western		12.25 100 4 0				
High grade 99.95		12.85 104 17 0				
High grade 99.99		13.25 107 6 0			1.10 92 10	
Thermic			1.20 88 13			
Electrolytic			1.28 94 13	191 111 10		13.00 104 0

Non-Ferrous Metal Prices (continued)

Ingot Metals

All prices quoted are those available at 2 p.m. 5/4/61

	£	s.	d.
Aluminium Alloy (Virgin)			
B.S. 1490 L.M.5 .... ton	210	0	0
B.S. 1490 L.M.6 .... „	202	0	0
B.S. 1490 L.M.7 .... „	216	0	0
B.S. 1490 L.M.8 .... „	203	0	0
B.S. 1490 L.M.9 .... „	203	0	0
B.S. 1490 L.M.10 .... „	221	0	0
B.S. 1490 L.M.11 .... „	215	0	0
B.S. 1490 L.M.12 .... „	223	0	0
B.S. 1490 L.M.13 .... „	216	0	0
B.S. 1490 L.M.14 .... „	224	0	0
B.S. 1490 L.M.15 .... „	210	0	0
B.S. 1490 L.M.16 .... „	206	0	0
B.S. 1490 L.M.18 .... „	203	0	0
B.S. 1490 L.M.22 .... „	210	0	0
Aluminium Alloys (Secondary)			
B.S. 1490 L.M.1 .... ton	171	0	0
B.S. 1490 L.M.2 .... „	174	0	0
B.S. 1490 L.M.4 .... „	180	0	0
B.S. 1490 L.M.6 .... „	181	0	0
***Aluminium Bronze**			
BSS 1400 AB.1..... ton	244	0	0
BSS 1400 AB.2..... „	251	0	0

	£	s.	d.
***Brass**			
BSS 1400-B3 65/35 .. ton	176	0	0
BSS 249 ..... „	—		
BSS 1400-B6 85/15 .. „	224	0	0
***Gunmetal**			
R.C.H. 3/4% ton .... „	—		
(85/5/5/5) LG2 ..... „	220	0	0
(86/7/5/2) LG3 ..... „	230	0	0
(88/10/2/1) ..... „	283	0	0
(88/10/2/½) ..... „	293	0	0
***Manganese Bronze**			
BSS 1400 HTB1..... „	196	0	0
BSS 1400 HTB2..... „	212	0	0
BSS 1400 HTB3..... „	229	0	0
Nickel Silver			
Casting Quality 12% „	240	0	0
„ „ 16% „	255	0	0
„ „ 18% „	295	0	0
***Phosphor Bronze**			
B.S.1400P.B.1.(A.I.D. released) ..... „	309	0	0
B.S. 1400 L.P.B.1 „	241	0	0

**Average prices for the last week-end.*

	£	s.	d.
Phosphor Copper			
10% ..... ton	256	0	0
15% ..... „	258	0	0
Phosphor Tin			
5% ..... „	898	0	0
Silicon Bronze			
BSS 1400-SB1 ..... „	284	0	0
Solder, soft, BSS 219			
Grade C Tinmans ... „	377	15	0
Grade D Plumbers .. „	301	15	0
Grade M ..... „	415	10	0
Solder, Brazing, BSS 1845			
Type 8 (Granulated) lb.	—		
Type 9 „ „	—		
Zinc Alloys			
BSS 1004 Alloy A .. ton	117	18	9
BSS 1004 Alloy B.... „	121	18	9
Sodium-Zinc ..... lb.		2	7

Semi-Fabricated Products

Prices vary according to dimensions and quantities. The following are the basis prices for certain specific products.

Aluminium			
Sheet 10 S.W.G. lb.	2	10½	
Sheet 18 S.W.G. „	3	0½	
Sheet 24 S.W.G. „	3	3½	
Strip 10 S.W.G. „	2	10½	
Strip 18 S.W.G. „	2	11½	
Strip 24 S.W.G. „	3	1	
Circles 22 S.W.G. „	3	4½	
Circles 18 S.W.G. „	3	3½	
Circles 12 S.W.G. „	3	2½	
Plate as rolled ..... „	2	10	
Sections ..... „	3	4	
Wire 10 S.W.G. .... „	3	1½	
Tubes 1 in o.d. 16 S.W.G. ..... „	4	4	
Aluminium Alloys			
BS1470. HS19W.			
Sheet 10 S.W.G. „	3	3	
Sheet 18 S.W.G. „	3	5½	
Sheet 24 S.W.G. „	4	1	
Strip 10 S.W.G. „	3	3	
Strip 18 S.W.G. „	3	4½	
Strip 24 S.W.G. „	4	0½	
BS1477. HP30M.			
Plate as rolled ..... „	3	1	
BS1470. HC15WP.			
Sheet 10 S.W.G. „	4	3	
Sheet 18 S.W.G. „	4	8½	
Sheet 24 S.W.G. „	5	8½	
Strip 10 S.W.G. „	4	4	
Strip 18 S.W.G. „	4	8½	
Strip 24 S.W.G. „	5	4½	
BS1477. HPC15WP.			
Plate heat treated ... „	3	10½	
BS1475. HG19W.			
Wire 10 S.W.G. „	4	2	
BS1471. HT19WP.			
Tubes 1 in. o.d. 16 S.W.G. ..... „	5	5	
BS1476. HE19WP.			
Sections ..... „	3	4	
Split tube			
19 S.W.G. (¼") ..... „	4	2	
20 S.W.G. (⅜") ..... „	3	11	
21 S.W.G. (⅜") ..... „	4	1	
22 S.W.G. (½") ..... „	4	11	
Welded tube			
14 to 20 S.W.G. (sizes ½" to 1¼") .... „	3/10½ to 5/8½		

Brass			
Tubes ..... lb.	1	9⅝	
Brazed Tubes ..... „	3	2⅝	
Drawn Strip Sections „	3	2¼	
Sheet ..... ton	196	15	0
Strip ..... „	196	15	0
Extruded Bar ..... lb.	2	0½	
Condenser Plate (Yellow Metal) ..... ton	186	0	0
Condenser Plate (Naval Brass) ..... „	198	0	0
Wire ..... lb.	2	8½	
Beryllium Copper			
Strip ..... „	1	4	11
Rod ..... „	1	1	6
Wire ..... „	1	4	9
Copper			
Tubes ..... lb.	2	1⅞	
Sheet ..... ton	259	5	0
Strip ..... „	259	5	0
H.C. Wire ..... „	275	15	0
Cupro Nickel			
Tubes 70/30 ..... lb.	3	5⅞	

Lead			
Pipes (London) ..... ton	107	0	0
Sheet (London) ..... „	104	15	0
Tellurium Lead ..... „	£6 extra		
Nickel Silver			
Sheet and Strip 10%.. lb.	3	10½	
Wire 10% ..... „	4	3½	
Phosphor Bronze			
Wire ..... „	4	1	
Titanium (1,000 lb. lots)			
Billet 4½" to 18" dia..... lb.	47/-	48/-	
Rod ½" to 4" dia..... „	85/-	53/-	
Wire ·036"-232" dia .... „	159/-	99/-	
Strip ·001" to ·048" .... „	350/-	68/-	
Sheet 8'×2'. 20 gauge „	73/-		
Tube, representative average gauge ..... „	198/-		
Extrusions ..... „	90/-		
Zinc			
Sheet ..... ton	122	5	0
Strip ..... „	nom.		

Domestic and Foreign

Merchants' average buying prices delivered, per ton, 4/4/61.

	£
Aluminium	
New Cuttings	141
Old Rolled	114
Segregated Turnings	79
Brass	
Cuttings	159
Rod Ends	143
Heavy Yellow	136
Light	130
Rolled	148
Collected Scrap	135
Turnings	136
Copper	
Wire	204
Firebox, cut up	201
Heavy	199
Light	196
Cuttings	206
Turnings	180
Braziery	176

	£
Gunmetal	
Gear Wheels	200
Admiralty	200
Commercial	184
Turnings	179
Lead	
Scrap	56
Nickel	
Cuttings	—
Anodes	550
Phosphor Bronze	
Scrap	184
Turnings	179
Zinc	
Remelted	76
Cuttings	66
Old Zinc	46

Financial News

American Metal Climax

The year 1960 was the best in the history of American Metal Climax Incorporated, Mr. Walter Hochschild, the chairman, and Mr. Frank Coolbaugh, the President, told stockholders in their annual report for the year ended December 31. Net income of 38,705,000 dollars, or 2.71 dollars per share of common stock, was 26 per cent above 1959 earnings of 30,833,000 dollars, or 2.15 dollars per share, and in excess of the previous record established in 1956. Total revenues from sales of molybdenum, uranium, copper, lead, zinc, potash, oil, and other products and services were 678,984,000 dollars, compared with 668,540,000 dollars in 1959.

The AMAX officials said dividend income, chiefly from foreign sources, was 23 per cent higher than in 1959. Most of these dividends were received from the four major non-ferrous mining companies located in Southern Africa in which AMAX has investments, but, as in 1959, dividends from these African sources were about 22 per cent of total earnings. These African mines all produced normally without interruption throughout 1960 and 1961 to date.

Follsain

Group net profit, 1960 £40,224 (£21,435). Dividend 15 per cent (12½ per cent). Fixed assets £294,180 (£264,771), current assets £470,740 (£358,784), and liabilities £287,877 (£199,856), including overdraft £93,625 (£57,478).

F. W. Berk and Co. Ltd.

The authorized share capital has been increased from £2,000,000 to £2,250,000 by the creation of 1,000,000 additional Ordinary shares of 5s. each. The agreement dated March 14, 1961, having been approved by the shareholders of Alluvial and General Industries (London) Limited, is now unconditional and pursuant thereto the new 1,000,000 Ordinary shares of Berk have been allotted credited as fully paid to Alluvial in satisfaction of the purchase consideration for the whole of the issued share capital of St. Albans Sand and Gravel Company Limited.

Permission to deal in and quotation for the new 1,000,000 Ordinary shares of Berk have been granted by The Stock Exchange, London. The new shares have been issued on renounceable letters of allotment and will rank *pari passu* in all respects with the existing Ordinary shares except that they will not rank for the final dividend of 6d. per share, less income tax, which the directors of Berk have recommended in respect of the year ended December 31, 1960.

New Companies

The particulars of companies recently registered are quoted from the daily register compiled by Jordan and Sons Limited, Company Registration Agents, Chancery Lane, W.C.2.

Aluminium Platers (Leeds) Limited (680877), Carr Mills, Meanwood Road, Leeds. Registered January 17, 1961. To take over business of electroplaters carried on as "Aluminium Platers (Leeds)", at Leeds, etc. Nominal capital, £6,000 in £1 shares. Directors: John D. Barber and Edgar M. Spenceley.

H. Cheetham and Son (Metals) Ltd. (682792), 16 Mount Street, Wrexham, Denbighshire. Registered February 8, 1961. To carry on business of merchants and dealers in scrap iron, metals, etc. Nominal capital, £10,000 in £1 shares. Directors: John W. Cheetham and Margaret M. Cheetham.

Jackman Anodised Products Limited (683540), 36 Southampton Street, W.C.2. Registered February 15, 1961. To carry on business of metal and alloy makers, anodizers, oxidizers, etc. Nominal capital, £100 in £1 shares. Directors: Harry Jackman and Mrs. Ursula R. Jackman.

Lovell Metals Limited (684132), Copthall House, Copthall Avenue, E.C.2. Registered February 22, 1961. Nominal capital, £100 in £1 shares. Directors: Sidney Lovell and Rosa V. Lovell.

Kenmont Metals Limited (684402), 28 Mallard Way, N.W.9. Registered February 24, 1961. Nominal capital, £100 in £1 shares. Directors: Derek H. Histead, Fredk. E. Histead and Wm. Marshall.

Scrap Metal Prices

The figures in brackets give the English equivalents in £1 per ton:—

France (new francs per kilo):		
Electrolytic copper scrap	(£218.0.0)	2.95
Heavy copper	(£218.0.0)	2.95
No. 1 copper wire	(£203.4.0)	2.75
Brass rod ends	(£164.1.0)	2.22
Zinc castings	(£67.19.0)	0.92
Lead	(£65.0.0)	0.88
Aluminium	(£134.9.0)	1.82
Italy (lire per kilo):		
Aluminium soft sheet clippings (new)	(£178.2.0)	305
Lead, soft, first quality	(£80.0.0)	137
Lead, battery plates	(£44.19.0)	77
Copper, first grade	(£214.2.0)	365
Bronze, commercial gunmetal	(£178.2.0)	305
Brass, heavy	(£148.18.0)	255
Brass, light	(£134.6.0)	230
Brass, bar turnings	(£148.18.0)	255
Old zinc	(£64.4.0)	110

Japan (Yen per metric ton):		
Electrolytic copper	(£—)	283,000
Copper wire No. 1	(£—)	265,000
Copper wire No. 2	(£—)	250,000
Heavy copper	(£—)	250,000
Light copper	(£—)	215,000
Brass, new cuttings	(£—)	200,000
Red brass scrap	(£—)	212,000
West Germany (D-marks per 100 kilos):		
Used copper wire	(£204.19.0)	225
Heavy copper	(£204.19.0)	225
Light copper	(£182.4.0)	200
Heavy brass	(£132.1.0)	145
Light brass	(£95.13.0)	105
Soft lead scrap	(£52.16.0)	58
Zinc scrap	(£52.16.0)	58
Used aluminium unsorted	(£81.19.0)	90

Trade Publications

General Purpose Furnaces. — Wild-Barfield Electric Furnaces Ltd., Otterspool Way, Watford By-Pass, Watford, Herts.

Two leaflets are devoted to horizontal and vertical general-purpose furnaces. Specifications, diagrams and photographs are included in each case.

Technical Data.—Croda Limited, Cowick Hall, Snaith, Goole, Yorks.

Two sets of technical data sheets have recently been issued by this company. One set deals with anti-corrosive and other protective materials made by the firm to Government and other official specifications. The other set deals with "Prevok", a general-purpose rust preventive.

Shears and Presses.—Joseph Rhodes and Sons Ltd., Belle Vue, Wakefield.

A series of four brochures is being distributed by this company describing their wide range of shears and presses. These include Hydraversal shears, fluid drive shears, stagger-feed presses, and C-frame presses. General data, diagrams and photographs are included in the description of these machines.

Light Metal Statistics

Figures showing the U.K. production, etc., of light metals for year 1960, have been issued by the Ministry of Supply as follows (in long tons):—

Virgin Aluminium	
Production	28,921
Imports	311,907
Despatches to consumers	353,878
Secondary Aluminium	
Production	129,812
Virgin content of above	20,184
Despatches (including virgin content)	127,781
Scrap	
Arisings	175,467
Estimated quantity of metal recoverable	126,271
Consumption by:	
(a) Secondary smelters	148,250
(b) Other uses	16,896
Despatches of wrought and cast products	
Sheet, strip and circles	181,942
Extrusions (excluding forging bar, wire-drawing rod and tube shell):	
(a) Bars and sections	47,782
(b) Tubes (i) extruded	4,292
(ii) cold drawn	8,319
(iii) formed strip	—
(c) (i) Wire	18,353
(ii) Hot rolled rod (not included in (c) (i)	742
Forgings	4,166
Castings: (a) Sand	21,203
(b) Gravity die	55,458
(c) Pressure die	26,997
Foil	27,267
Paste	3,530
Magnesium Fabrication	
Sheet and strip	179
Extrusions	1,420
Castings	2,201
Forgings	122

THE STOCK EXCHANGE

Prices Remained Firm

ISSUED CAPITAL *	AMOUNT OF SHARE	NAME OF COMPANY	MIDDLE PRICE 30 MARCH +RISE—FALL	DIV. FOR LAST FIN. YEAR	DIV. FOR PREV. YEAR	DIV. YIELD	1961 HIGH	1961 LOW	1960 HIGH	1960 LOW
£	£			Per cent	Per cent					
4,435,792	1	Amalgamated Metal Corporation ...	32/3 —3d.	11	9	6 16 6	32/6	26/3	35/–	26/6
400,000	2/–	Anti-Attrition Metal	1/–	NIL	4	NIL	1/–	0/9	1/6	0/9
43,133,593	Stk. (£1)	Associated Electrical Industries ...	45/–xd —1/–	15	15	6 13 3	54/10½	40/3	67/3	38/3
3,895,963	1	Birfield	56/9 +9d.	10	15‡	3 10 6	56/9	45/–	51/3	29/–
4,795,000	1	Birmid Industries	87/9 +9d.	20	20D	4 11 3	87/9	71/3	74/9	56/–
8,445,516	Stk. (10/–)	Birmingham Small Arms	36/6 +1/–	17½QT	12½	3 4 0	36/6	24/9	30/6	18/3
203,150	Stk. (£1)	Ditto Cum. A. Pref. 5%	14/6	5	5	6 18 0	14/4½	14/–	17/4½	14/9
476,420	Stk. (£1)	Ditto Cum. B. Pref. 6%	16/6	6	6	7 5 6	17/6	16/9	20/–	17/1½
500,000	1	Bolton (Thos.) & Sons	48/9	12½	10	4 6 6	48/9	37/6	43/–	36/–
300,000	1	Ditto Pref. 5%	14/– —3d.	5	5	7 2 9	14/6	13/9	16/–	14/3
1,500,000	Stk. (£1)	British Aluminium Co. Pref. 6% ...	17/–	6	6	7 1 3	18/–	16/6	21/1½	17/7½
18,846,647	Stk. (£1)	British Insulated Callender's Cables	57/3 +3d.	13½	13½	4 14 3	58/6	50/4½	61/4½	47/–
20,456,599	5/–	British Oxygen Co. Ltd., Ord. ...	33/6 +1/6	16	16	2 7 9	31/10½	26/3	35/–	19/10½
1,200,000	Stk. (5/–)	Canning (W.) & Co.	18/9 —9d.	15 + 8½C	25 + *2½C‡	4 0 0	20/–	13/7½	19/9	13/7½
60,484	1/–	Carr (Chas.)	1/6 +1½d.	NIL	12½	—	1/6	1/–	2/3	1/–
555,000	1	Clifford (Chas.) Ltd.	29/–	12	10	8 5 6	29/–	26/–	35/–	28/9
46,000	1	Ditto Cum. Pref. 6%	15/3	6	6	7 17 6	15/3	15/1½	16/–	15/10½
300,000	2/–	Coley Metals	3/9	15	15	8 0 0	4/2½	3/6	5/–	3/4½
10,185,696	1	Cons. Zinc Corp.†	71/3	20	15	5 12 3	72/–	64/–	80/9	59/6
5,399,056	1	Davy-Ashmore	176/– —1/6	30‡	20	1 14 3	179/–	129/6	147/3	99/6
8,000,000	5/–	Delta Metal	24/4½	20	17½	4 2 0	25/4½	19/9	28/3	18/6
5,296,550	Stk. (£1)	Enfield Rolling Mills Ltd.	51/–	15	15	5 17 9	52/3	45/–	56/9	45/–
1,155,000	1	Evered & Co.	45/–	10B	10φ	2 19 6	45/–	42/6	42/9	29/3
18,000,000	Stk. (£1)	General Electric Co.	36/6 +6d.	10	10	5 9 6	39/6	29/6	47/9	29/–
1,500,000	Stk. (10/–)	General Refractories Ltd.	59/–	25	20	4 4 9	59/9	42/9	52/6	40/–
937,500	5/–	Glacier Metal Co. Ltd.	17/6	13	11½	4 2 3	17/9	13/9	16/1½	11/1½
2,500,000	5/–	Glynwed Tubes	28/– —3d.	22½	25¶	4 0 3	30/–	23/7½	27/6	17/–
7,228,065	10/–	Goodlass Wall & Lead Industries ...	41/–	19L	16	3 10 9	41/9	34/9	41/9	33/–
696,780	10/–	Greenwood & Batley	25/6xcap	30W	30	5 17 9	27/–	23/9Z	33/6	29/1½
792,000	5/–	Harrison (B'ham) Ord.	12/9 —6d.	*20‡	*17½	3 18 6	13/6¾	12/3	15/10½	11/9
150,000	1	Ditto Cum. Pref. 7%	20/–	7	7	7 0 0	20/3	20/–	23/6	22/–
1,612,750	5/–	Heenan Group	15/4½xd	13	15	4 4 6	15/6	10/6	13/–	9/10½
251,689,407	Stk. (£1)	Imperial Chemical Industries ...	72/– +1/3	13¾	11½	3 15 0	72/–	63/1½	76/6	54/–
34,736,773	Stk. (£1)	Ditto Cum. Pref. 5%	15/–	5	5	6 13 3	15/9	14/10½	18/–	15/4½
29,196,118	**	International Nickel	123½	$1.60	$1.50	2 7 0	126	104	105	84¾
300,000	1	Johnson, Matthey & Co. Cum. Pref. 5%	14/6	5	5	6 18 0	14/10½	14/–	16/6	14/6
6,000,000	1	Ditto Ord.	61/9 —6d.	12	12D	3 17 6	62/9	59/6	67/6	44/9
600,000	10/–	Keith, Blackman	21/–	17½	17½E	8 6 9	21/–	18/3	32/6	17/6
320,000	4/–	London Aluminium	11/1½ +4½d.	12	10	4 6 3	11/1½	8/6	12/6	7/10½
765,012	1	McKechnie Bros. Ord	58/– +1/9	17½F	15F	6 0 9	58/–	53/6	71/6	57/3
1,530,024	1	Ditto A. Ord.	56/6 +1/6	17½F	15F	6 3 9	56/6	53/3	69/3	55/–
1,108,268	5/–	Manganese Bronze & Brass	18/3	20%	20%	5 13 0	18/6	14/–	18/6	13/4½
50,628	6/–	Ditto (7½% N.C Pref.)	5/6	7½	7½	8 3 9	6/–	5/6	6/6	5/9
26,361,444	Stk. (£1)	Metal Box	88/– +6d.	12M	13B	2 10 0	88/3	68/3	84/3	61/–
416,760	Stk. (2/–)	Metal Traders	8/–	50	50	12 10 0	8/3	6/9	10/9	7/1½
160,000	1	Mint (The) Birmingham	38/6 +1/–	10	10	5 4 0	38/6	36/–	39/–	33/6
80,000	5	Ditto Pref. 6%	76/3	6	6	7 17 6	77/6	76/–	80/–	75/–
5,187,938	Stk. (£1)	Morgan Crucible A.	62/6	13	12	4 3 6	63/–	53/4½	63/–	47/6
1,000,000	Stk. (£1)	Ditto 5½% Cum. 1st Pref. ...	15/6	5½	5½	7 2 0	17/–	15/3	18/9	15/9
3,860,000	Stk. (£1)	Murex	46/– +3d.	22½J	15	5 12 0	46/–	39/9	45/–	35/3
585,000	5/–	Ratcliffs (Great Bridge) Ord. ...	16/3 +3d.	10	10R	3 1 6	16/6	16/–	17/–	14/9
195,000	5/–	Ditto 8% Max. Ord.	5/–	8	—	8 0 0	5/–	4/10½	5/3	5/–
1,064,880	10/–	Sanderson Kayser	36/9 —6d.	35‡	25	4 15 3	38/–	33/9	40/3	27/7½
3,400,500	Stk. (5/–)	Serck	17/9	12½	17½GD	3 10 6	18/3	15/–	25/6	15/3
8,035,372	Stk. (£1)	Stone-Platt Industries	66/– —6d.	15	15	4 11 0	66/10½	55/–	64/4½	52/3
2,928,963	Stk. (£1)	Ditto 5½% Cum. Pref.	15/6	5½	5½	7 2 0	15/9	15/–	18/7½	15/3
35,344,881	Stk. (£1)	Tube Investments Ord.	83/– +6d.	14	20	3 7 6	84/6	72/3	140/3	63/10½
41,000,000	Stk. (£1)	Vickers	32/– —3d.	10	10	6 5 0	33/3	28/–	39/7½	27/1½
750,000	Stk. (£1)	Ditto Pref 5%	13/–	5	5	7 13 9	13/6	12/7½	17/6	13/3
6,863,807	Stk. (£1)	Ditto Pref. 5% tax free	20/–	*5	*5	7 8 9A	20/7½	19/9	24/6	20/1½
4,594,418	1	Ward (Thos. W.) Ord.	77/3 —6d.	13¾	25	3 11 3	77/9	64/6	94/–	63/–
7,109,424	Stk. (£1)	Westinghouse Brake	41/–	11	10	5 7 3	41/7½	36/4½	60/6	37/6
323,773	2/–	Wolverhampton Die-Casting ...	9/9	35	30	7 3 6	10/2½	9/–	13/10½	8/1½
591,000	5/–	Wolverhampton Metal	29/6 +9d.	32½	27½	5 12 0	29/3	24/6	39/9	23/9
156,930	2/6	Wright, Bindley & Gell	4/– +1½d.	15	20‡	9 7 6	4/3	3/7½	4/3	2/10½
124,140	1	Ditto Cum. Pref. 6%	13/6	6	6	8 17 9	13/7½	13/6	15/–	13/6
150,000	1/–	Zinc Alloy Rust Proof	5/–	40	30	8 0 0	5/3	4/6	5/4½	4/–

*Dividend paid free of Income Tax. †Incorporating Zinc Corpn. & Imperial Smelting. **Shares of no Par Value. ‡ and 100% capitalized issue. ¢The figures given relate to the issue quoted in the third column. A Calculated on £7 8 9 gross. D and 50% capitalized issue. C paid out of Capital Profits. E and 50% capitalized issue in 7% 2nd Pref. Shares. R and 33⅓% capitalized issue in 8% Maximum Ordinary 5/– Stock Units. φ and 6⅔% from Capital Profits B and 50% capitalized issue. G and 1½d. special distribution. F and special 5% tax free dividend. H As forecast. ¶And 3 for 7 capitalized issue. L and 33⅓% capitalized issue. M and 10% capitalized issue. J and 75%capitalized issue. S and 40% capitalized issue. O calculated at 13⅓%. Interim on smaller capital P Calculated at 11⅓%. Q also 1/– special tax free dividend and 50% capitalized issue. T Per £1 unit. W Before capital reorganization. Calculated at 15%. Z After capital reorganization

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A Reverbale in a Coventry foundry melted 5,227.5 lb. of metal in 8 hours 10 minutes using 42.5 gallons of fuel oil. **Fuel consumed per hour of operation — 5.2 gallons. Fuel consumed per lb. of metal — 0·008 gallons**

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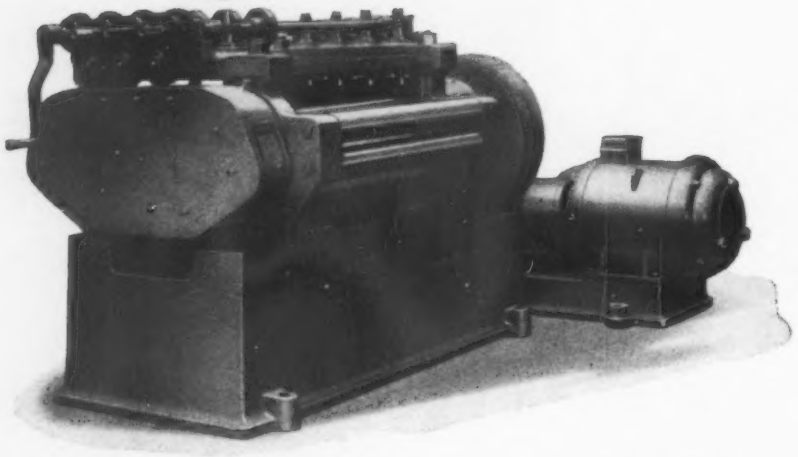
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ANNEALING FURNACES FOR NON-FERROUS MATERIALS

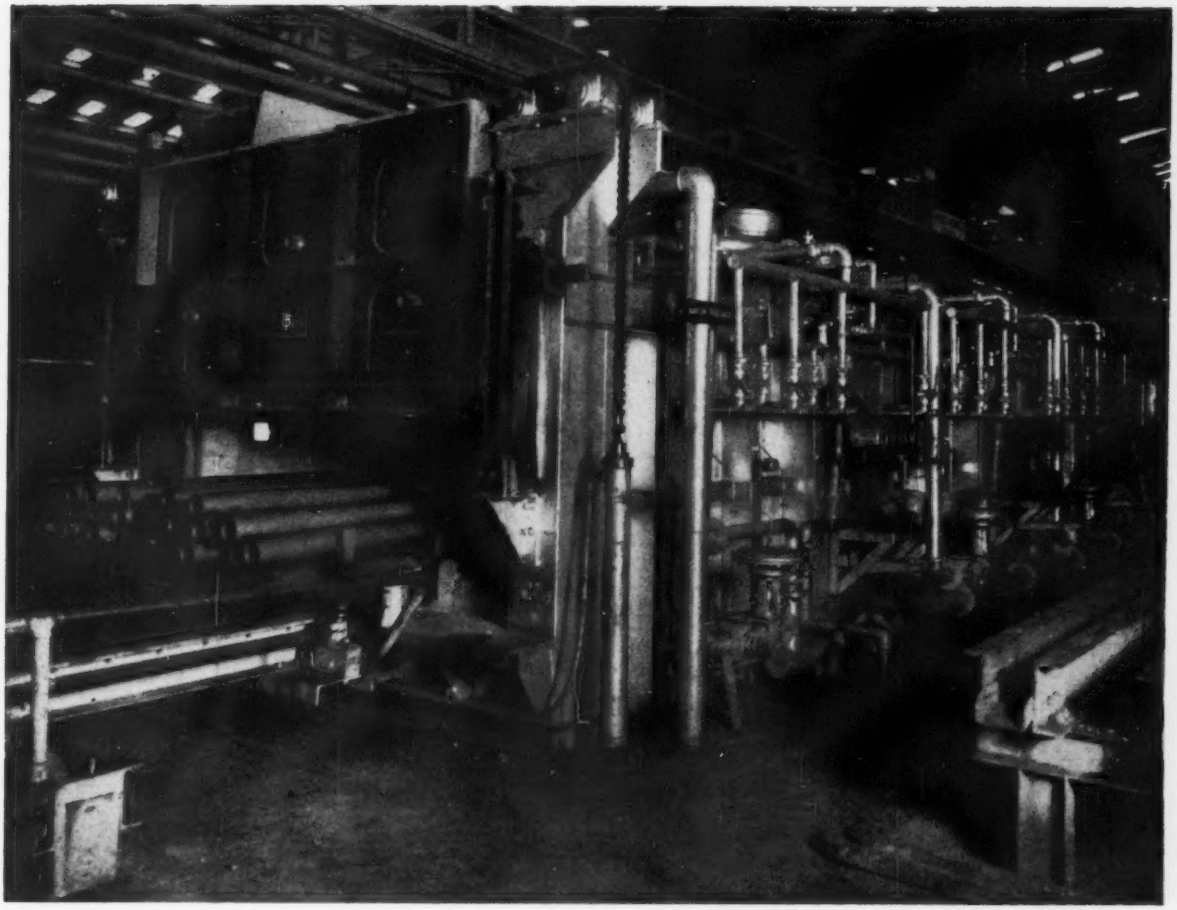


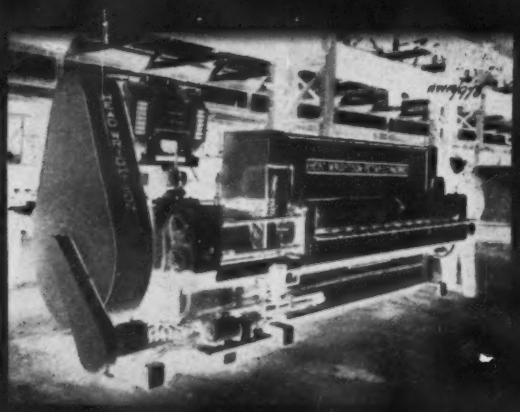
Illustration by kind permission of The Yorkshire Imperial Metals Ltd.

Batch Type Annealing Furnace, Town's Gas Fired. 8′ 0″ wide × 30′ 0″ long for non-ferrous tubes, operating temperatures 250°-800°C. Output 3 Tons per hour. Automatic proportioning gas burners give atmosphere control with uniformity of temperature and economy in operation.

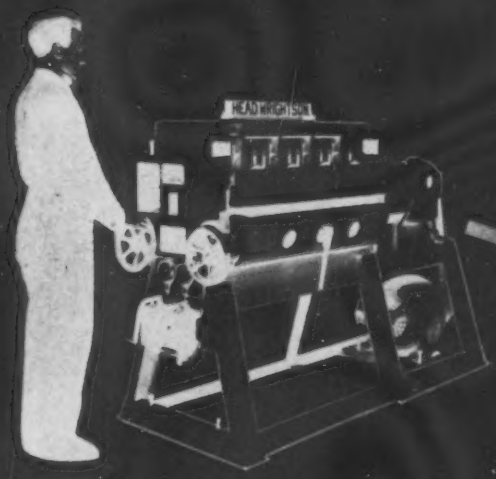
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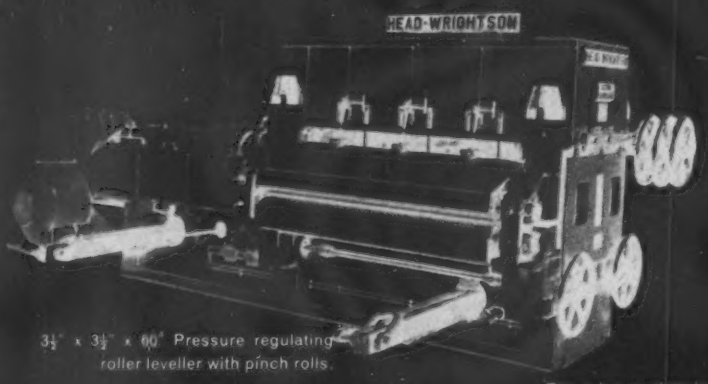
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$2\frac{1}{2}$" x $2\frac{1}{2}$" x 102" Processor leveller.

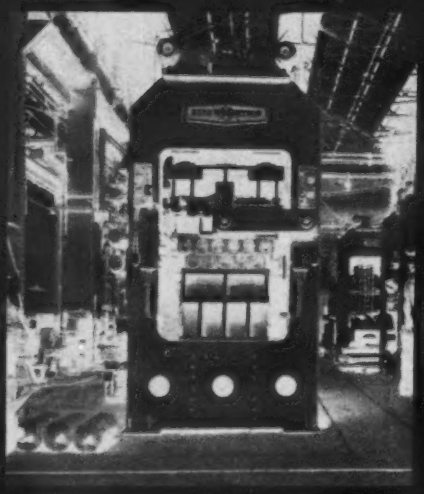


$1\frac{1}{8}$" x $1\frac{1}{8}$" x 36" Pressure regulating roller leveller, with four banks of back-up rolls for levelling aluminium foil.

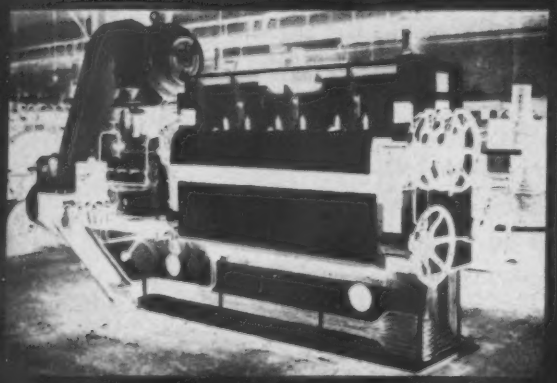




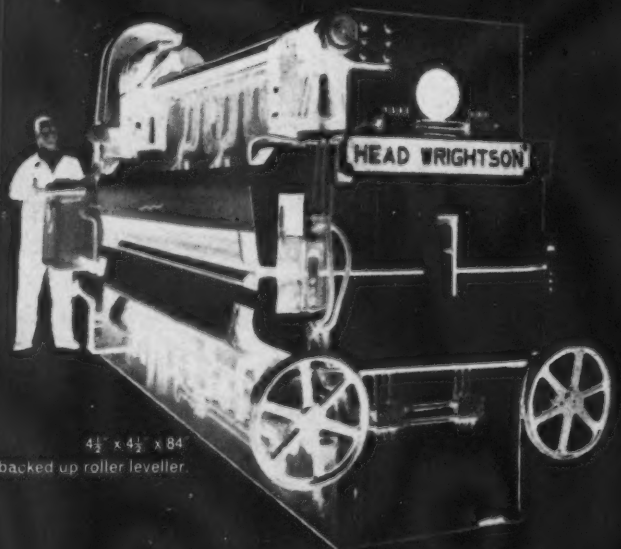
$3\frac{1}{2}$" x $3\frac{1}{2}$" x 60" Pressure regulating roller leveller with pinch rolls.



Three heavy plate levellers capable of levelling plate 12ft wide by $2\frac{1}{2}$ inches thick being built at the company's works.



$1\frac{1}{2}$" x $1\frac{1}{2}$" x 54" Pressure regulating roller leveller.

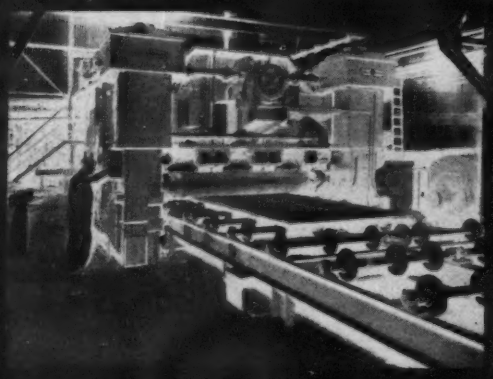


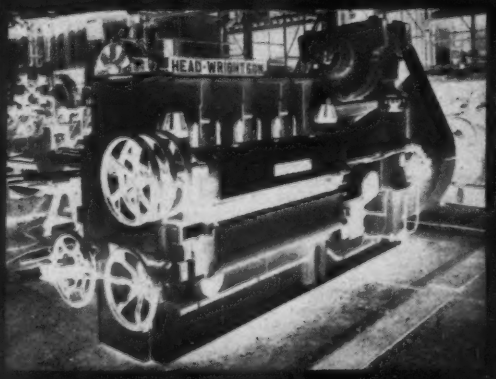
$4\frac{1}{2}$" x $4\frac{1}{2}$" x 84" backed up roller leveller.

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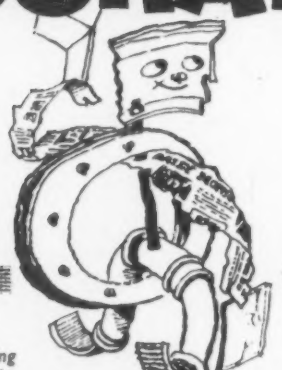
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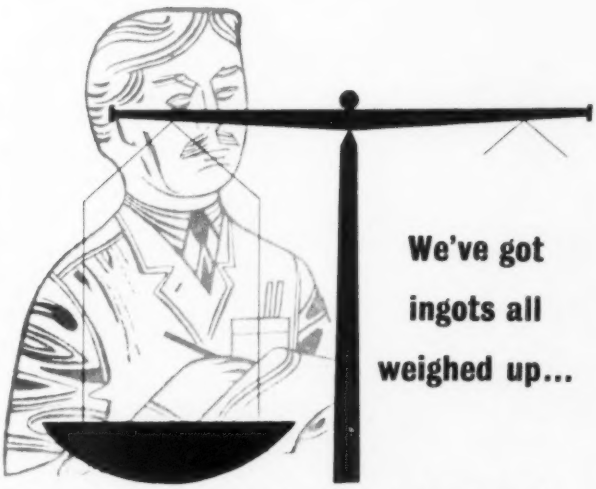
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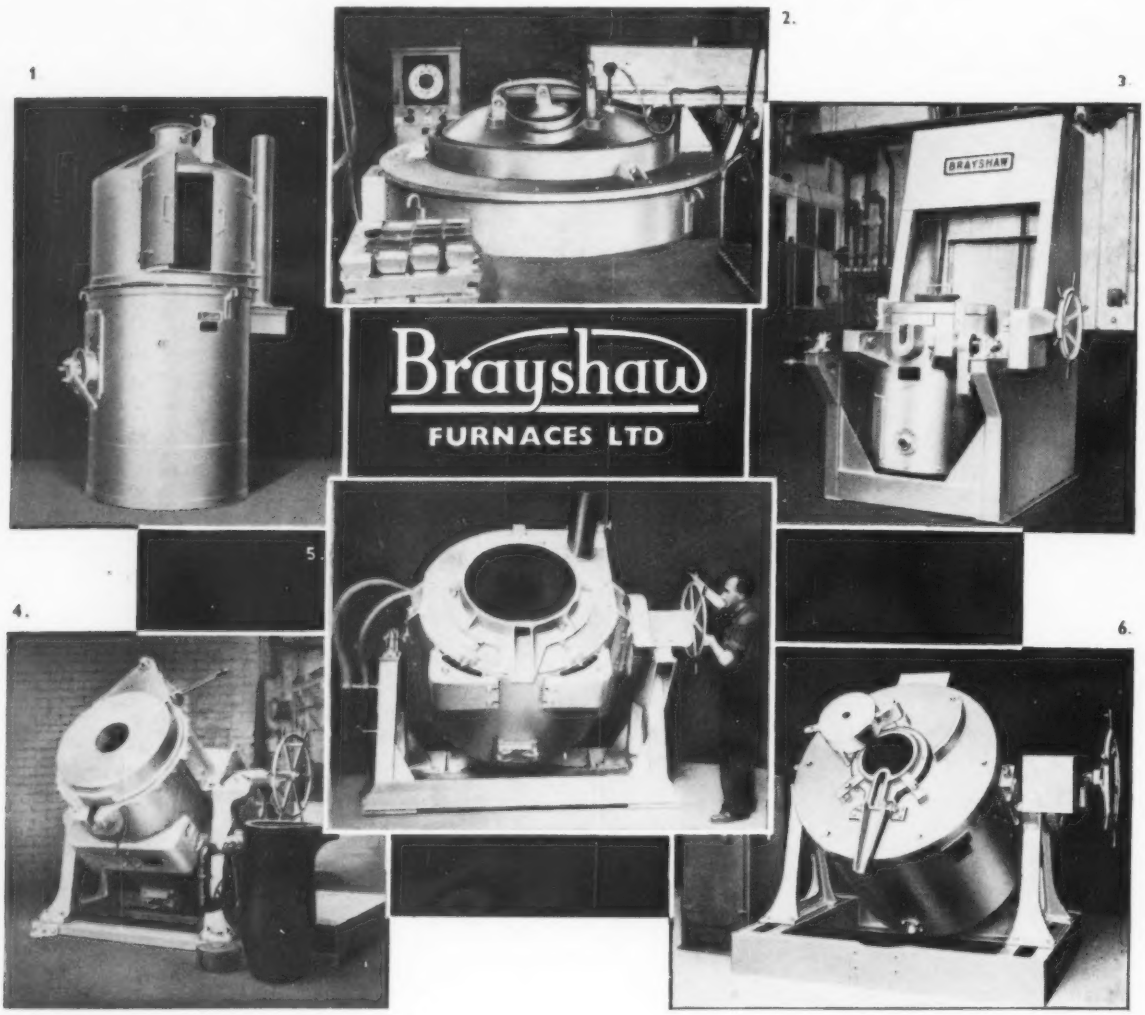
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